INTRODUCTION TO

MALARIA PROBLEM IN INDIA

INTRODUCTION

TO

MALARIA PROBLEM IN INDIA

Dossabhoy Hormusjee Cama Prize Essay 1944
University of Bombay
Revised and brought uptodate

BY

LIEUT COLONEL B L RAINA
ARMY MEDICAL CORPS

With an Introduction by

DR JIVRAJ N MEHTA
M D (London) M R C P (London)

NEW BOOK CO LTD
188-90 HORNBY ROAD FORT
BOMBAY
1951

By the same author

FAMILY PLANNING WHY WHEN & HOW

HEALTH & HOW TO KEEP IT (WHAT TO EAT & WHY)

1951

Published by P F Dinshaw for New Book Co Ltd 188 190 Hornby Road Fort Bombay and Printed by S N Guha Ray at Sree Saraswaty Press Limited 32 Upper Circular Road Calcutta 9

INTRODUCTION

This brochure by Dr Rama which is an elaboration of the thesis he submitted to the University of Bombay and for which he was awarded the Dossabhoy Cama prize by the Syndicate of the University is as the title indicates an Introduction to the Malaria Problem in India The author deals with the problem in various aspects He explains it by saying that the heavy toll taken by the disease whether of the civil population or of the Army is such as to make it imperative for the authorities to be less apathetic and the people less ignorant about it The author has by facts and figures shown how greatly malaria contributes both directly and indirectly to the high mortality as well as morbidity in this country He has also shown that more soldiers have died of malaria than by enemy action and yet the author points out that more is done to combat diseases like plague cholera etc than to combat malaria This neglect on the part of authority as well as of the people is due as stated by the author to the fact that the havoc caused by malaria is not so glaringly perceptible as that caused by say plague or cholera He is therefore right in bringing the fact to the public notice that apart from the high mortality due to malaria it is a disease which along with hookworm so widely distributed in rural areas saps the vitality of the nation and is therefore a greater enemy of the people and must not be neglected any longer

The author gives a brief but interesting history of the efforts made to find out the causes of malaria and also the various method of combating it He finally says The solution of the malaria problem in India requires serious consideration of five principal factors viz (1) education (2) organization (3) medical protection (4) legislation and (5) funds

No one will dispute the fact that health education should form part of general education of the child The non recognition of this fact has made us pay heavily in

Plasmod um v vax Figs 1 13 (Original)

1 2 Young trophozoite ring forms 3 5 Growing tr ph forms Parasites show marked amæbo d acti ity Corpuscl s are enla ge l pale and show Schüffner s dots Granules of pigment are sc tt r throughout the cytoplasm in figs 4 and 5 6 8 De el p ng schiz nt 9 Mature sch zont The pigment has collected into a loose mas 1 formation of merozoites has taken place 10 Mature microg met cyte The chromatin is d ffuse an l the cytoplas n stains a pale blue col 11 Mat re macrogametocyte The cytoplasm stains de p blue T chromat n is compact and stains deeply 12 Sch zont an l gam t cyt with n the same corpuscles 13 Two schizonts w th in the same corpu l

Plasmod um falcipar m Figs 14 31 (Original)

14 Yo ng ring form 15 Young ring form w th doubl ch o at n l ts 16 17 Multit de inl ction of corpuscles also howing marg nal or *acc lé* forms 18 21 Tenue forms correspond ng to *Plas o l m t* Steph ns 1914 22 23 Large ring forms T1 infected corpuscles h w Maurer s dots 24 Growing trophozoite form from a culture The p ra te has lost th vacuole and a jet black comp ct mass of p gment ha appeared 25 27 De elop ng schizonts fron a c ltu 28 29 Matu sch ont from a culture 30 Mature m ı rogametocyte 31 Mat re macrogam tocyte

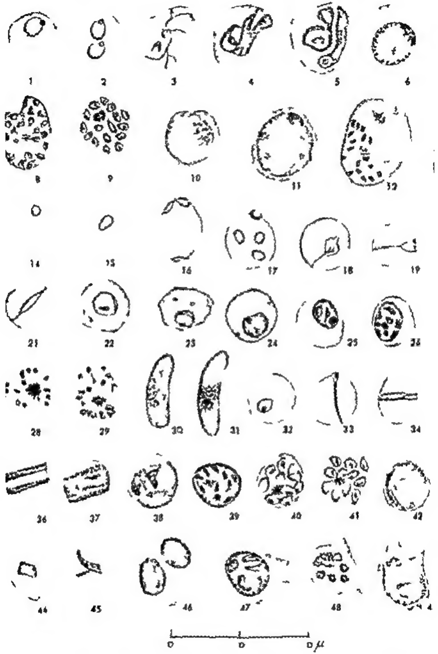
Pl mod um mal r æ Figs 32-43 (Orig nal)

32 Young ring form 33 36 Grow ng tropho oit form showing charact rist c band forms 37 Larg rectangular band form 38 39 De v l p ng sch zonts 40 41 Mature schizonts 42 Mat re mic ogam to- yt 43 Mature macrogam tocyte

Pla mod um o ale Figs 44 50 (After Jame 1933)

44 45 Grow g tropho o tes 46 47 De elop ng schizont 48 Ma ture schizont 49 M crogam tocyt 50 Macrogam tocyt

MALARIA PARASITES OF MAN



(From Knowles's Introduction to Medical Protozoolo
edited by B M Das Gupta 1944)

Courtesy The Director School of Tropical Medicin

ed & Printed by Sree Saraswaty Press Ltd Calcutta

CHAPTER I

HISTORY

Malarial fever is not a new phenomenon in the medical [illegible] of India. Some of the earliest references to this [illegible] occur in the *Atharva Veda* believed to have been [com]posed about 1500 B.C. It was classified even in *Atharva* [Veda] according to the periodicity of attack of fever, i.e. [quotidian] (*sadandim*), tertian (*trtiyakam*) and quartan [(*... *]*yam*). It was also classified according to the season [in] which the fever made its appearance, viz. winter (*sitam*), [summer] (*graismam*) and rainy season (*vārsikam*). It was [c]ommon especially where there was excessive rain [(*ma*]*haavrsah*) or too much grass (*mūjavanta*). It also leads [t]o the assumption that such fevers were common in *[Gandhara]* (Peshawar District and Hoti Mardan), *Anga* [(c]ountry about Bhagalpur) and *Magadha* (Bihar State).

[t]rtiyakam vitrtiyam sadānd nuta śāradam
takmānam ś itam ruram graismam nāśaya vā sikam

A.V. V.22.13

oko asya mujavanta oko asya mahāvrsāh
[y]āvajjātastakmamstāvānasi Balhikesu nyocarah

A.V. V.22.5

From the numerous references to it and analysis of its characteristics it would appear that malaria was the commonest type of fever. Its association with mosquito may be surmised by the descriptions which give nearly all the characteristics and habits of mosquitoes, especially needle like proboscis (*kusūlā*), bloody mouth (*lohitāsyān*) and the habit of visiting the dwellings after sunset (*salah pari viśanti sāyam*). There is also reference to the use of odourous or fumigating medications used to destroy them.

In ka 5 sukta 22, reference is made to *takman*. Caraka and Susruta use the word *Jvara* for fever in general. It continues to be the group name of all diseases with fever as the main and dominating sign. These authors of the Ayurvedic period classify fever into five types instead of four of *Atharva Veda*, viz. continuous (*Santatah*), remittent

(*Satatah*) quotidian (*Anyedyuskah*) tertian (*Trtiyakah*) and quartan (*Caturthakah*)

ye salah parinrtyanti sayam gardabhanadinah
kusuli ye ca kuksilah kakubhah karubhah srimah
tanosadhe tvam gandhena tis cinan vinasaya

A V VIII 6 10

ye kukundhah kukurabhan krttivd rsani bibhrati
kliba iva pranrtyanto vane ye kurvate ghosam tanito nasayamasi

A V VIII 6 11

ye suryam na titiksanta atapantamamum divah
a ayan bastivasino durgandhimlloi itasyan makkan nasayamasi

A V VIII 6 12

ye suryat parisarpanti snuseva svasuradadhim
bajasca tesam pingasca hrdayedhinirvidhyatam

A V VIII 6 24

Punah pancavidho drsto dosakalabalabalat
samtatah satato nyedyustrtiyakacaturthakah

Ca Ci 3 34

Anyedyuskah pratidinam dinam hitva trtiyakah
Dinadvayam yo visramya pratyeti sa caturthakah

Ca Ci 3 67

Saptaham va dasaham va dvadasahamathapi va
Santatya yo visargi syut santatah sa nigadyate
Ahoratr satatako dvau kalavanuvartate
Anyedyuskastvahoratradekakalam pravartate
Trtiyakastrtiye hni caturthe hni caturthakah

Su U 39 69 70 71

The similes given by these two authors to explain the advent and periodicity of this kind of fever are very significant Caraka for instance compares the phenomena to the seed sown in the ground which takes one day to grow in case of quotidian two days in case of tertian and three days in case of quartan when they grow up they invade the whole body and not being counter acted by anti bodies (*pratyanika*) they cause the fever When the force of these invading elements is exhausted they return to their original habitat and again begin to grow up Susruta compares the advent of fever to the tide and ebb of the ocean Caraka s account of the life history of malarial parasite is of special interest Both the authors also state that this kind of fever is common in low land or land at the foot of the mountain Besides these indirect references to malaria we find in the Susruta Samhita a direct reference to five species of mosquitoes viz sea born globular in shape the huge type black in colour and the mountainous The bite of the mountainous species (*Parvatiya*) is stated to bear the same characteristics as that of deadly insects (*Pranahara*

Kita Damsana) Later references to malarial mosquitoes or malarial fever in *Vāgabhaṭa Mādhava* and *Bhāvamisra* are simply repetitions of the statements made by these two authors Presumably the use of mosquito-nets (*masaka hari*) was also prevalent in India as would be evident from Marco Polo s account as early as the 13th A D

Adhilete yathā bhumau bijani kāle ca ahate
Adhilete tathā dhātum doṣah kāle ca kupyati
Sa vrdhi h b lakālam ca p āpya doṣastṛtsy ham
Catu thah m ca ku nta praty ahabal kiyāt
Krttā n g m gatabalāh sve sve sthā vyavasthitāh
I u v ṛdhāh sve kāle pra ayanti naram malāh

Ca Ci 3 68 69

Yathā vegāgame velām chādayitvā mahodadheh
Vegahā au tad vāmbhastat a vāntarmit yate
Dosavegodaye tadvaduď yete jvaro sya vai
Vegahā au p saāmyete yathā mbhah sāg re t thā

Sa U 39 73 74

Maśakah—sāmudrah parimandalo hastimaśakah krṣnah pārvat ya iti pa ca te dastarye t v a hā d damsatophalca pārvat yastu h t h p ā ah a si lyalahla ah

Su Ka 8 36

It will be obvious therefore that malaria as a disease and its association with the mosquito was known as early as the Vedic period in ancient India ; The word for mosquito in the *Atharva Veda* is *makka* which is the same as *masaka* in classical Sanskrit The derivatives of the word mosquito in different Indo-European languages point out that an insect of this kind can be traced back to great antiquity *

Fevers recurring periodically and cases with enlarged spleens were referred to by Hippocrates Empedocles is reported to have freed Selinus from fever in 550 B C by draining the marshes Egyptian Greek and Roman writers associated malaria with marshes and bad air Varro 127 16 B C and Columella about 116 B C refer to minute animals and noxious streams in marshes Cicero wrote about a temple of fever Goddess in Palatine Godfry

Greek — μ =fly
Latin —Musca = a fly
Sanskrit —Maśaka = a mosquito from the root maś (= to hum)

All these derivatives point to a common origin and this must be a word in the Indo-European language when the Aryan families had not migrated one to Greece and the other to India i e before the splitting up of Indo-European language into Sanskrit, Greek Latin etc

(*Satatah*) quotidian (*Anyedyuskah*) tertian (*Triyakah*) and quartan (*Caturthakah*)

ye śalah parinṛtyanti sayam gardabhanadinah
kusula ye ca kukśilal kakubhah karubhah srimah
tanosadhe tvam gandhena visucinan vinaśaya

A V VIII 6 10

ye kukundhah kukurabhak krittivd rśani vibhrati
kliba iva pranṛtyanto vane ye kurvate hoṣam tanito vi ayatha

A V VIII 6 11

ye suryam na titikṣanta atapantamamum divah
arāyān bastivasino durgandhuhilohitasyan makkin nāśay masi

A V VIII 6 12

ye suryat parisarpanti snuseva śvasuradadhim
bajaśca tesim pingaśca hrdayēdhimividhyatām

A V VIII 6

Punah pancavidho drsto dosakalabalābalāt
samtatah satato nyedyustrtiyakacaturthakah

Ca Ci 3 34

Anyedyuskah pratidinam dinam hitva trtiyakah
Dinadvayam yo viśrasya pratyeti sa caturthakah

Ca Ci 3 67

Saptāham vā daśāham va dvadaśahamathapi va
Santatya yo visargi syat santatah sa nigadyate
Ahoratre satatako dvau kalāvanuvartate
Anyedyuskastvahoratradekakalam pravartate
Tri yakastrtiye hni caturthe hni caturthakah

Su U 39 69 0 71

The similes given by these two authors to explain the and periodicity of this kind of fever are very signi Caraka for instance compares the phenomena to the seed sown in the ground which takes one day to grow in case of quotidian two days in case of tertian and three days in case of quartan when they grow up they invade the whole body and not being counter acted by anti bodies (*pratyanika*) they cause the fever When the force of these invading elements is exhausted they return to their origi nal habitat and again begin to grow up Susruta compares the advent of fever to the tide and ebb of the ocean Caraka s account of the life history of malarial parasite is of special interest Both the authors also state that this kind of fever is common in low land or land at the foot of the mountain Besides these indirect references to malaria we find in the Susruta Samhitā a direct reference to five species of mosquitoes viz sea born globular in shape the huge type black in colour and the mountainous The bite of the mountainous species (*Pārvatīya*) is stated to bear the same characteristics as that of deadly insects (*Prānahara*

Kita Damsana) Later references to malarial mosquitoes or malarial fever in *Vāgabhata* *Mādhava* and *Bhavamisra* are simply repetitions of the statements made by these two authors Presumably the use of mosquito-nets (*masaka hari*) was also prevalent in India as would be evident from Marco Polo s account as early as the 13th A D

Adh lete yathā muh bijam kāle ca rohati
Adhilete tathā dhātum dosah kāle ca kupyati
Sa v dh balakālam prāpya dosastrtiyakam
Cat thakam ca ku ute praty kabalahiyāt
Kṛtvā vegam gatabelāh sve sve sthā e vyavasthitāh
I a vitṛdhāh sve kāle jva ayanti na om malāh

Ca Ci 3 68 69 o

Yathā vegāgame velāṁ chādayitvā mahodadheh
Vegahā au tadevāmbhastat e vā tarnu yat
D savegodaye tadvadudī yete jv o sya va
Vegahānau p alāmyeta yathā mbhah sāgare t thā

Su 39 73 74

Maśakah—sāmud ah par nandalo hastimaśkah kṛṣnah pārvat ya iti pa ca ta dastasya t v a hānd r damsatophatca pārvatyastu k tesh pvā aharaistulyalakśanah

Su Ka 8 36

It will be obvious therefore that malaria as a disease and its association with the mosquito was known as early as the Vedic period in ancient India The word for mosquito in the *Atharva Veda* is *makka* which is the same as *masaka* in classical Sanskrit The derivatives of the word mosquito in different Indo-European languages point out that an insect of this kind can be traced back to great antiquity *

Fevers recurring periodically and cases with enlarged spleens were referred to by Hippocrates Empedocles is reported to have freed Selinus from fever in 550 B C by draining the marshes Egyptian Greek and Roman writers associated malaria with marshes and bad air Varro 127 16 B C and Columella about 116 B C refer to minute animals and noxious streams in marshes. Cicero wrote about a temple of fever Goddess in Palatine Godfry

Greek —μυια = fly
Latin —Musca = a fly
Sanskrit —Maśaka = a mosquito from the root maś (= to hum)

All these derivatives point to a common origin and this must be a word in the Indo-European language when the Aryan families had not migrated one to Greece and the other to India i e before the splitting up of Indo-European language into Sanskrit, Greek Latin etc

surgeon described the malaria parasite at Constantine in Algeria Italians considered them as degenerated red cells They considered that *Bacillus malariae* isolated from water and soil by Klebs and Crudeli in 1879 was the causative organism By 1885 Laveran s theory was accepted In 1884 Gerhardt had produced an attack of malaria by injecting blood of malaria patient Golgi and his collaborators Marchiafava and Celle in Italy reported different species of malaria parasites Romanowsky s chromatin staining method since 1891 further facilitated observations and research Koch distinctly showed three species of malaria

It remained for Major Ronald Ross of the Indian Medical Service and Grassi and his colleagues to explode once and for all the theory of malaria based on bad air and decomposing vegetation Ross when on short leave to Sigur Ghat in 1896 while investigating cases of malaria found that 80% of the labourers had enlarged spleens He had a severe attack of malaria himself before he returned to his duties in the army On the constant persuasion of Sir Patrick Manson (who it may be stated formulated the hypothesis of mosquito transmission theory in 1894 and stimulated the interest of Ross in the theory and showed him the malaria parasite for the first time in London Hospital) Ross continued his investigations On the 20th August 1897 in Secunderabad he made his epoch making discovery (demonstrating the malaria parasite in a mosquito that had fed on blood with malaria parasite) and completed on the 9th July 1898 the life cycle of the malaria parasite of avian malaria (*Plasmodium praecox*) in mosquitoes Grassi Bignami and Bastianelli worked out the complete development for human malaria in *Anopheles maculipennis* and transmitted the disease to man by the bite of the infected mosquito Two years after Sambon Low and Terzi lived in a mosquito proof house in Ostia an intensely malarious locality in Roman Campagna and remained free from malaria Mosquitoes fed on malaria patients were sent from Rome to London and were made to bite other patients Dr P Manson and Mr George Warren volunteered and both of them developed severe attacks of malaria leaving no doubt that malaria is caused by a parasite harboured in

the blood of human beings and is carried from man to man by the female mosquito of a certain species Full advantage of these discoveries was not taken for long despite the heavy toll taken by malaria

In the world about 300 000 000 people suffer from malaria In India out of the total deaths in 1931 60% were due to fever (¼ at least being due to malaria) and only 5% were due to the much dreaded group of diseases like plague and cholera Statistics covering the period 1932 to 1941 reveal that the malaria death rate approximates 37% of the total number of deaths in India

The incidence of malaria is of a still greater importance in war as it often incapacitates more troops than battle casualties Many military operations have been brought to a standstill by malaria Covell (1943) observed that the very nature of an army s normal activities is such that almost every action it performs in a malarious country is calculated to promote the spread of the disease viz the constant movements of troops by night and day the employment of large numbers of men on night duties the difficulties of enforcing measures of personal protection the aggregation of large bodies of labourers the consequent introduction of new strains of malaria among the troops the camping of troops in close proximity to malarious villages for strategic reasons the dispersion of troops over large areas instead of concentrating them in easily protected camps difficulties of transport shortage of anti malaria equipment and drug and the impossibility of ensuring that drugs are actually taken in the dosage and manner prescribed

During the Walcheren expedition of 1809 out of 40 000 4000 died from fever as against 668 killed in action During the Rangoon expedition of 1804 05 there were only 35 deaths from wounds but 450 out of every 1000 men engaged died of malaria In the Burma expedition of 1824 the enterprise in Arakan had to be abandoned owing to fever for everyone who was not dead was in hospital (75% of the whole force in action) In 1916 18 malaria came into its own In Macedonia over 170 000 British troops were admitted to hospital (January to May 1916

150 cases June to December 1916 30 000 cases 1917 70 000 cases 1918 over 60 000 cases, 25 000 resistant cases re patriated and two million days were lost) In East Africa there were 107 702 admissions giving the highest rate per thousand Napoleon in 1809 is reported to have written to one of his ministers We rejoice to see that the English themselves are in the morasses of Zeeland only keep them in check and the bad air and fevers peculiar to the country will soon destroy them In 1942 in Assam and Arakan (before anti malaria measures were brought into full force) *history once again repeated itself* In April 1942 a large railway project was rendered ineffective as 90% of the labourers were down with malaria In the same year a quarter of the force in the Assam front became casualties *from a small winged enemy—Anopheles mini mus* In 1943 ratio of casualties from wounds to sickness was 1 121 The total casualty rate per 1000 strength of Indian other ranks was 1128 9 i e statistically every soldier was more than once in hospital *Half the sick suffering* from all diseases were suffering from malaria In three months October to December 1942 18 000 cases mostly malaria were evacuated by the Eastern Army Field Marshal Lord Wavell instructed the G O Cs in C that In theatres where future operations are likely to take place we may well find that disease and especially malaria is a more dangerous factor than enemy resistance We have already had experience of the effects of a bad malarial season in Assam We must prepare to meet malaria by training as strict and as earnest as against enemy troops We must be as practised in the use of our weapons against it as we are with the rifle we must study the habits of the mos quitoes as we do the tactics of the Japanese We must know methods of anti mosquito work as well as how to con struct trenches to hold a position

Soon after malaria control measures were taken the malaria rate rapidly dropped In 1945 malaria incidence was reduced to one tenth of what it was in 1943 Over the whole Allied Land Forces South East Asia the malaria sick rate dropped from 3 65 per 1000 to 0 20 per 1000 It can be confidently said that successful war against malaria

as the major factor in the success of the Allies against the Japanese

Effects of malaria in peace time are not so dramatic as of diseases like plague or cholera Malaria imperceptibly saps the vitality diminishes the normal expectation of life of those that survive dislocates labour and industry and retards the economic and social progress of the country as a whole It has been responsible for accelerating the physical and intellectual degeneration of the people in tropics for centuries

The live birth rate begins to fall after the malaria season sets in and the reduction is most pronounced about a month after the epidemic is at its height Watson (1924) pointed out that when women get into a malarious locality they rarely become pregnant and when pregnant soon abort Brahmachari (1923) observed in a severe malaria epidemic that apart from a rise in malaria mortality of 100 the recorded non malaria death rate rises 2½ times Malaria affects children and particularly those who are still in their teens destroys their blood cells and renders them anaemic and stunted both physically and mentally There can be no gainsaying that the malaria is one of the greatest problems which faces India

It not only has a baneful influence on the growth of the population but by lowering their vitality renders them more liable to contract other infections It has been estimated that at least two million persons die in India every year due to the direct and indirect effects of malaria and at least 125 to 175 million suffer from it resulting in great loss of life widespread misery and in money unbelievable millions of pound sterling annually (Sinton 1939)

Malaria takes its toll in some places all the year round and in others seasonally and periodically The Northern and Western parts of the Indo-Pakistan sub-continent show marked seasonal incidence Christophers reported that during the 1908 epidemic many villages and even whole Thanas showed high mortality during October and November—in some instances as high as 300 400 and even 500 per mille During years of abnormal epidemics total numbers of deaths may increase by ¼ to ½ million The rela

Chapter II

THE PARASITE

There are three main species of malaria parasites—the parasites are protozoa class *Sporozoa* sub-order *Haemosporidia* genus *Plasmodium*—*Plasmodium vivax* (Grassi and Feletti 1890) causing benign tertian malaria *P malariae* (Laveran 1881) quartan malaria and *P falciparum* (Welch 1897) malignant tertian malaria There is a fourth plasmodium called *P ovale* (Stephens 1922) * It is rare and almost limited to Africa and causes mild tertian fever Each of these has asexual cycle (schizogony) in man and sexual cycle (sporogony) in the female anopheline mosquito The different types of plasmodia differ in morphology but their life history is essentially the same The parasite in man undergoes a series of changes It is seen like a pale disc on or within a red blood cell with black or reddish black particles scattered in the cytoplasm Particles collect in the centre round which the cytoplasm arranges itself into segments Finally the red blood cells break down liberating the segments called merozoites These merozoites adhere to other red cells enter them and grow at the expense of the haemoglobin and repeat the same cycle After several generations of merozoites a few develop into sexual forms (male or macro and female or micro gametocytes) The sexual forms cannot develop any further in the human body When taken by a specific mosquito macro and microgametocytes join (syngamy) and form a zygote The zygote bores its way through the epithelium of the stomach of the mosquito encysts between the epithelium and the limiting membrane and becomes an oocyst in which numerous slender motile spindle shaped bodies about 12 15μ called the sporozoites are formed The oöcyst ruptures when liberating the sporozoites into the caelomic cavity These sporozoites are motile and get collected in the salivary

* *P tenue* (Stephens 1914) is of a doubtful species Man has also been experimentally infected with *P knowlesi* a parasite of monkeys

glands of the mosquito and are injected with the salivary secretion into the human body when the mosquito next feeds The history of human malaria parasite after being injected into man by the mosquito till it appears in the circulating red blood cells remained a mystery till recently Shortt *et al* (1948a) reported the pre-erythrocytic forms of *P cynomolgi* (a malaria parasite of the monkeys) in liver on the sixth and seventh days of incubation period It was assumed that the life of *P vivax* in man would resemble that of *P cynomolgi* as seen in the liver of *Macaca mulata* The above presumption was finally proved at Horton hospital Aylrabury where a large number of *A maculipennis atroparvus* infected with *P vivax* were fed upon a patient and isolated salivary glands of the infected mosquitoes were inoculated intravenously into the same patient The biopsy was performed several days after The material examined showed plasmodial masses studded with chromatin particles very similar in appearance to those previously seen in the case of infection of the monkey with *P cynomolgi* The forms seen measured up to 42 μ in diameter and showed in some instances the vacuoles noted in the case of *P cynomolgi* (Shortt *et al* 1948b)

Thus the asexual and sexual forms of the malaria parasite develop in man and mosquito respectively The infected red cells in man rupture and release the merozoites to infect fresh cells This coincides with the rise of temperature and shivering The attack of fever may occur in one type (quartan) every 72 hours or every 4th day in the other two types (benign and malignant tertian) every 48 hours or every third day and in still other types daily or at irregular intervals (mixed infection) A person gets fever after not less than 10 to 14 days of the bite of the mosquito About 10 days after the attack of fever the sexual forms mature in man If the mosquito of the carrier species feeds on an infected man having these sexual forms it takes the parasite about two weeks to develop into the sporozoite provided climatic conditions are suitable for maturation of the malaria parasite in the mosquito and the blood feed has been taken from a person carrying the sexual forms which are fully mature

Chapter II

THE PARASITE

There are three main species of malaria parasites—the parasites are protozoa class *Sporozoa* sub-order *Haemosporidia* genus *Plasmodium—Plasmodium vivax* (Grassi and Feletti 1890) causing benign tertian malaria *P malariae* (Laveran 1881) quartan malaria and *P falciparum* (Welch 1897) malignant tertian malaria There is a fourth plasmodium called *P ovale* (Stephens 1922) * It is rare and almost limited to Africa and causes mild tertian fever Each of these has asexual cycle (schizogony) in man and sexual cycle (sporogony) in the female anopheline mosquito The different types of plasmodia differ in morphology but their life history is essentially the same The parasite in man undergoes a series of changes It is seen like a pale disc on or within a red blood cell with black or reddish black particles scattered in the cytoplasm Particles collect in the centre round which the cytoplasm arranges itself into segments Finally the red blood cells break down liberating the segments called merozoites These merozoites adhere to other red cells enter them and grow at the expense of the haemoglobin and repeat the same cycle After several generations of merozoites a few develop into sexual forms (male or macro and female or micro gametocytes) The sexual forms cannot develop any further in the human body When taken by a specific mosquito macro and microgametocytes join (syngamy) and form a zygote The zygote bores its way through the epithelium of the stomach of the mosquito encysts between the epithelium and the limiting membrane and becomes an oocyst in which numerous slender motile spindle shaped bodies about 12 15μ called the sporozoites are formed The oöcyst ruptures when liberating the sporozoites into the caelomic cavity These sporozoites are motile and get collected in the salivary

* *P tenue* (Stephens 1914) is of a doubtful species Man has also been experimentally infected with *P knowlesi* a parasite of monkeys

glands of the mosquito and are injected with the salivary secretion into the human body when the mosquito next feeds The history of human malaria parasite after being injected into man by the mosquito till it appears in the circulating red blood cells remained a mystery till recently Shortt *et al* (1948a) reported the pre-erythrocytic forms of *P cynomolgi* (a malaria parasite of the monkeys) in liver on the sixth and seventh days of incubation period It was assumed that the life of *P vivax* in man would resemble that of *P cynomolgi* as seen in the liver of *Macaca mulata* The above presumption was finally proved at Horton hospital Aylrabury where a large number of *A maculipennis atroparvus* infected with *P vivax* were fed upon a patient and isolated salivary glands of the infected mosquitoes were inoculated intravenously into the same patient The biopsy was performed several days after The material examined showed plasmodial masses studded with chromatin particles very similar in appearance to those previously seen in the case of infection of the monkey with *P cynomolgi* The forms seen measured up to 42 μ in diameter and showed in some instances the vacuoles noted in the case of *P cynomolgi* (Shortt *et al* 1948b)

Thus the asexual and sexual forms of the malaria parasite develop in man and mosquito respectively The infected red cells in man rupture and release the merozoites to infect fresh cells This coincides with the rise of temperature and shivering The attack of fever may occur in one type (quartan) every 72 hours or every 4th day in the other two types (benign and malignant tertian) every 48 hours or every third day and in still other types daily or at irregular intervals (mixed infection) A person gets fever after not less than 10 to 14 days of the bite of the mosquito About 10 days after the attack of fever the sexual forms mature in man If the mosquito of the carrier species feeds on an infected man having these sexual forms it takes the parasite about two weeks to develop into the sporozoite provided climatic conditions are suitable for maturation of the malaria parasite in the mosquito and the blood feed has been taken from a person carrying the sexual forms which are fully mature

The infected cell becomes enlarged in size in *P vivax* infection The infected erythrocytes of *P falciparum* clump together and adhere to the walls of the capillaries leading to serious complications associated with malignant subtertian infection Another notable feature of *P falciparum* infection is that the cells may be infected with three or more sets of parasites concurrently each causing a continuous paroxysm of fever

The incubation period differs in the different species about a week to 12 days in malignant tertian about two weeks in benign tertian and about three weeks in quartan infection

Benign tertian infection is usually of a persistent type though it may have a low parasite count Symptoms are usually mild despite chill and high fever and paroxysms last for about ten hours *P vivax* like *P falciparum* can sometimes give rise to severe cerebral symptoms (Dhayagude and Purandare 1943) Joint pains herpes labialis and gastro intestinal symptoms especially vomiting are often noted Malaria cases with symptoms of acute intestinal obstruction have been described Relapses after as many as 10 to 20 years have been recorded Rigors with fever are seen in both benign tertian and quartan Nephritis has been occasionally found Hyperpyrexia is seen especially with *P falciparum* infection and is a dangerous symptom Paroxysms of fever may last twenty to thirty hours and may show a double peak and no chill Mild febrile attacks of long duration anaemia black water fever together with pneumonic cardiac psychotic and algid types, are not uncommon in the tropics

The parasites show regional distribution and seasonal preference One species may be prevalent in one season and another at a different period due to variations of temperature and humidity at different times If meteorological conditions remain uniform no change may be observed

P vivax seems to predominate from March to July and *P falciparum* from July to December reaching maximum incidence in May and October respectively

In areas where only one species of parasite is predominant infection with the predominant species is found

and in those areas where two or three parasites are found a person can be infected with one or more of them Differ ent seasonal changes too may affect prevalence of mixed infection Gametocytes also show variations It is stated that relative output is lowest in *P falciparum* on the other hand its increased rate of shizogony ensures that its abso lute output of gametocytes is higher than in either of the other two species Knowles *et al* suggest that the propor tion of gametocytes may depend on long duration of infection age of patient (basal metabolism) administration of drugs and the season of the year when examination is made Mixed infections constitute about 3 7% of the general malaria of the world and may be distributed as follows —

P vivax plus *P malariae* 9 1% *P vivax* plus *P falci parum* 79% *P malariae* plus *P falciparum* 10 4% *P vivax* plus *P malariae* plus *P falciparum* 1 5%

Knowles *et al* (1930) give the following distribution —

Provinces	*P vivax*	*P malariae*	*P falciparum*	*Mixed*	*No examined*	*No positive*
N W F P	37 8	0 3	61 9	5 0	17 000	8814
Punjab	58 4	1 0	40 6		2 707	2310
Delhi	54 4	1 2	44 4		1 694	1130
Rajputana	90 0%		10 0%			
U P including Nepal	70 0	3 9%	26 1	7 0	3 843	1830
C P	59 0%	11 8	30 2		2 209	935
Bombay including Goa	55 4	5 9	38 7%	56	16 275	7437
Mysore State	69 4	2 0	28 6		1 900	559
Hyderabad Deccan	35 6	9 7%	54 5%			174
Coorg	28 0	24 0%	48 0%			416
Madras Presy	57 8	7 0%	35 2%		4 596	1699
Agency Tracts	41 0	41 0%	18 0			575
Bihar Orissa	49 4	1 2	49 2	4 0	1 478	722
Bengal Presy	41 4	12 3%	46 3	265	19 860	8520
Assam	36 3	9 9	53 9	74 over	7 814	3068

This gives an over-all distribution as follows —

P vivax	47 1
P malariae	6 9
P falciparum	45 9

The average gametocyte output of the three species (Calcutta findings) is, for *P vivax* 21 2% *P malariae* 44 7% *P falciparum* 18 9% Great variations are found especially in the case of *P falciparum* (Knowles *et al*) It may be added that the distribution of the various species is not clearly understood Distribution of *P malariae* in general seems to be limited by summer isotherm of 60°F, *P falciparum* by 70°F *P malariae* appears to be a dying species maximum output of *P falciparum* occurs often towards the close of transmission period

Deaderick reported the following percentages of relapses —

P vivax	65%
P malariae	55%
P falciparum	45%

It will be seen that all plasmodia can cause further acute attacks of malaria *P vivax* relapses are extremely com mon and the relapse rate is probably higher than quoted above The study of therapeutically induced malaria shows that benign tertian relapses occur first within three months of the primary attack and the second between the sixth and the ninth month of the first attack and the malig nant tertian relapses within three months of the first attack It may be added that lower bodily resistance from disease or malnutrition chill over exertion and fatigue also tend to precipitate relapses

REFERENCES

DHAYAGUDE R G AND PURANDARE N M (1943) *Arch Pathology* 36 550-58

KNOWLES R SENIOR WHITE R AND DAS GUPTA B M (1930) *Ind J Med Res Mem* 18 43 101 298 306

SHORTT H E GARNHAM P C C AND MALAMOS B (1948a) *Brit Med J* Jan 31 192

SHORTT H E GARNHAM P C C COVELL G AND SHUTE P G (1948b) *Ibid* March 20, 547

CHAPTER III

THE MOSQUITO

There are approximately 1700 species of mosquitoes in the world but of these only about 180 are anophelines and out of these about 17 only are important carriers of malaria * Forty three species and 9 variants of anopheline mosquitoes have been identified in India and Pakistan out of which about 7 are chief vectors of this disease and a few others are of lesser importance

In their life cycle all mosquitoes pass through four stages of development The fertilized eggs are laid by the adult female mosquito on water Anopheline eggs are boat shaped and are laid singly and have distinctive markings They develop into larvæ which lie parallel to the surface of the water and feed on aquatic vegetation dead or living and on animal life The larvæ moult four times in two days to several months and after their fourth moult develop into comma shaped pupæ For a few hours to as many as a few days the pupa rests on the surface of water the skin then splits and the adult mosquito emerges †

* About 60 species of Anopheles have been incriminated in the world as carriers but there may be others not yet reported

† The *Anophelines* and *Culicines* eggs larvæ pupæ and adults can be distinguished from the following characteristics —

	Anophelines	*Culicines*
Eggs	Boat shaped Dorsolateral floats transversely or radially arranged Collect into clumps giving triangular and star shapes	Micropylar spinous process at head end Collect in rafts of hundreds of eggs
Larvæ	Aperture on 8th abdominal segment Float parallel to the surface of water	Long or short syphon tube on 8th abdominal segment Float head down with syphon tube on surface
Pupæ	Spiracles short stumpy and funnel shaped	Spiracles longer slender and trumpet shaped
Adult mosquitoes	Long and club shaped palpi in male Palpi as long as proboscis in female When resting appear to stand on its head except a few species	Long and tapering palpi in male Palpi bud like shorter than proboscis in female Proboscis bent at angle with body Rest parallel to the surface

are laid and where the larvæ breed the water is usually still Ovipositing females avoid flowing water even when the velocity is as low as one foot in 20 seconds Larvæ are unable to resist a current velocity greater than ·29 foot per second The larvæ are also strongly attracted to shade This attraction is so great that the larvæ will leave unshaded zones of still water in favour of shaded zones where the current may be sufficient to flush them downstream The thermal death point of the larvæ is 41 F The maximum water temperature of typical *A minimus* running water breeding places seldom exceeds 35 C It is very sensitive to pollution by decomposing vegetation and this sensitivity may be one of the deciding factors for the gravid female to avoid oviposition in polluted water collections The relation of ferruginous water to breeding places seems to depend on lack of food (algæ) for the larvæ and not to any larvicidal action of colloidal iron Silt by itself has no marked lethal action on *A minimus* larvæ The controlling effect attributed to silt is due to increase in current velocity *A minimus* lays more eggs in the monsoon but their expectation of life is greater at the end of the rainy season In the hot damp monsoon *A minimus* takes two days to digest a blood meal and develop its ovaries ovipositing occurs in the second night after feeding In cold weather this period is increased to 4-6 days In the dry zones of the Dooars the most important breeding places during cold weather are perennial seepages and small streams It feeds mostly on human beings Dark houses are preferred as resting places and 90 per cent of feeding takes place after midnight Natural infections are high during the months of March June August and September

A philippinensis Ludlow 1902 This species is found in Assam East and West Bengal Bihar Bombay Deccan Chhota Nagpūr Konkan Madras Coast North Malabar Mysore and Orissa It is an important vector in the plains of Bengal where it breeds in clear cool water with aquatic vegetation (especi *Hydrilla v* *Ceratophyllum demersum U* and *Na* filamentous green algæ expo D water hyacinth blue green and C

algæ of family Cynophyceae especially *Microcystis æruginosa* are inhibitory to breeding of the larvæ Subsoil water seems to bear inverse relation to the density of the breeding the lower the subsoil water level the higher is the density of this species In East and West Bengal the adult mosquito is found mainly in human habitations (Krishnan 1940 Iyengar 1944) In Assam however it is zoophilic and is normally found in cattle sheds (Ramsay 1944) The usual resting places in the houses are on the wall within a few feet of the floor They bite usually from 8 P M to 10 P M and 2 A M to 4 A M

A stephensi Liston 1901 This species is a vector in Western North western Peninsula and Northern parts of Indo-Pakistan sub-continent Bombay City Bangalore parts of Uttar Pradesh Tanna Tracts of Chinwari District Bhausi Tract of Amraoti District and Rupzar Tract of Bala ghat It breeds in wells tins roof gutters tanks tubs seepages swamps marshes and irrigation channels It can breed in water contaminated with sewage (Roy 1931) It has been reported breeding in salt pans during September and October in Bombay (Banaj 1943) Adults are strong fliers and may fly up to about 3 miles

A stephensi var *mysorensis* Sweet and Rao 1937 It is found in Poona Sind Vizagapatam Mysore State and usually breeds in irrigation channels margins of streams and wells It is the chief rural carrier of malaria in Vizagapatam (Senior White 1943)

A sundaicus Rodenwaldt 1926 It is found on the Arakan coast in Sunderbans in Hoogly Estuary Coastal Belt of Orissa Coastal Regions of Burma lower Bengal Madras State in salt lakes of Calcutta and Vizagapatam It breeds in brackish water partially cleared mangrove swamps artificial basins in which tidal water and fresh water mix and is often associated with algæ (*Enteromorpha Cladophora Cyanophyceæ*) *Oscillatoria germinata Lyngbya confervoides Oedogoniumsp* and dead aquatic vegetation (*Potamogeton pectinatus Halophila ovata* bound by alga *Lyngbya aestuarii*) They bite both in the day and night feed on human beings and can fly for over a mile for their food

Carriers of Local Importance

A annularis Van der Wulp 1884 It is a carrier in parts of Bengal and Orissa Coastal Plain (Senior White and Rao 1943) It has once been reported infected in nature at Ferozepur (Adie 1903) It breeds in still stagnant waters and pools tanks burrow pits and is often found associated with floating vegetation (*Hydrilla verticillata Ceratophyllum demersum*) and algal growth (Spirogyra) Even slow movement of water is not favoured by its larvæ The adults are found in houses in maximum numbers during August or September and in cowsheds during October and November During September October and the first half of November the adults appear to live longer and feed on human beings in preference to cattle

A jeyporiensis var *candidiensis* Koidzumi 1923 This species is found in Assam Bengal, Uttar Pradesh and Malabar Iyengar (1934) reported 4 gut infections out of 3833 dissected in Travancore It has been reported infected in nature in extreme South East Bengal (Arakan) It breeds in slow running streams and rivers with grassy edges also in lakes swamps seepages and ditches

A leucosphyrus Donitz 1901 It is found in Assam Bengal Konkan Madras Malabar and Mysore State It is reported to be a carrier in Digboi Assam (Clark and Chaudhury 1941) It usually breeds in partially shaded slow running grassy edged streams It feeds freely on human beings in Assam 75% out of 102 examined were found with human blood (Ramsay *et al* 1936)

A maculatus Theobald 1901 This species is widely distributed in the submontane tracts in the North South and East of Indo-Pakistan sub-continent and
of the Himalayas up to 8 000 feet It breeds i
pools and river beds in sunshine and
cattle It bites human beings
after which it leaves the houses
banks (Venhuis 1941) and is of r

A superpictus Grassi 1899
Baluchistan Waziristan and the
found east of the river Indus

are seepages rivers streams irrigation channels reservoirs and springs It appears to have marked preference for running water exposed to sunlight especially along the edges of streams and masses of spirogyra The adult mosquito rests outdoors in caves *karezes*

A varuna Iyengar 1924 It is found in Assam Bengal, Bihar, Bombay Chhota Nagpur Gujerat Konkan, Madras East Coast Malabar Mysore Orissa and Uttar Pradesh *It has been found infected in nature* in Travancore (Mathew 1939) Hooghly Delta (Iyengar 1928) Calcutta (Roy 1939) Jeypore Singhbhum Hills and appears to be of no importance elsewhere It seems that there are two different biological races *one in eastern coast of India and the other in the hills of Central India and Bengal Delta* It breeds in terraced rice fields irrigation channels streams seepages and roadside storm water drains Adults are found in cowsheds and human habitations

CARRIERS OF LITTLE OR NO IMPORTANCE

A aconitus Donitz 1902 This is found in Assam Bengal Bihar Madhya Pradesh Hyderabad Konkan, Madras North Coast Malabar Orissa and Uttar Pradesh *Two specimens were reported infected (1 gut 1 gut and* gland) out of 24 dissected at Chandpur Bengal (Das 1943) One gut infection was reported from Jeypore Hills out of 107 dissected (Senior White 1937) and one gut infection out of 1145 dissected from Lakhimpur Goalpara District It *breeds in swamps ponds irrigation channels rice fields* roadside drains and tanks with grassy margins Adults are found in houses and cowsheds

A jeyporiensis James 1902 This is found in Assam Bengal Bombay Deccan Central India Madhya Pradesh *Uttar Pradesh* Chhota Nagpur Gujerat *Hyderabad State,* Konkan Madras State Malabar and Mysore State Two gut infections out of 674 dissected in Mysore State were found (Nursing Rao and Sweet 1934) Senior White (1937) reported *four gut infections* out of 318 dissected in *Jeypore Hill Tract* Ramsay *et al* (1936) *recorded one gut* infection out of 3115 dissected It breeds *in* streams

irrigation channels, edges of ponds and lakes Adults are mostly found in cattle sheds

A karwari James 1903 This species is found in Assam Bengal Bihar Bombay Deccan Chhota Nagpur Konkan Malabar Mysore State and Orissa One gut infection out of 125 specimens dissected in Assam (Strickland 1929) and no infection in 15000 dissected (Ramsay *et al* 1936) have been reported It breeds in springs pools cool stream, swamps and seepages Adults are found both in cattle sheds and human habitation but mainly feed on cattle

A kochi Donitz 1901 Ramsay (1930) reported only two gut infections out of 77 dissected in July at Cachar Assam (total dissected in the year 2113) It breeds in small pools irrigation channels streams containers and split bamboos It feeds both on men and animals

A pallidus Theobald 1901 This has been reported infected in nature from Chanda Madhya Pradesh (Kenrick 1914) Krishnagar Bengal (24 per cent gut infection Sur and Sur, 1929) Birnagar Bengal (Bose 1931) Birbhum Bengal (0 03% sporozoite rate Timbres 1935) Udaipur State (0 7 per cent gland infection Roy and Biswas 1942) Senior White and Adhikari 1940 reported only four infected out of 3157 dissected in the East Satpura Ranges It breeds in borrow pits rice fields and tanks Adults are mostly found in cattle sheds

A pulcherrimus Theobald 1902 It breeds in swamps pools and collections of stagnant water Adults are frequent in both cattle sheds and human habitation It is a strong flier

A ramsayi Covell 1927 Only one gland infection was reported out of 287 dissected in Assam by Ramsay in 1930 No further infection has been reported (Ramsay 1943) It is found in Assam Bengal Bihar and Orissa and breeds in tanks pools and swamps with vegetation especially *Pistia stratiotes* Adult mosquitoes rest in both cowsheds and human habitation

A splendidus Koidzumi 1920 It has been reported infected in nature from Saharanpur (Robertson 1910) and Karnal (Macdonald and Majid 1931) It breeds in small

pools seepages tanks and streams with algæ Adults a found in cattle sheds and houses

A subpictus Grassi 1899 It has been reported infec ed in nature at Pattukkottai Madras State (1 gut and 1 g and gland out of 13277 dissected Russell and Rao 194 Two gut infections were also found positive in Ennore o of 4728 dissected (Russell and Jacob 1939) It breeds collections of water borrow pits roof gutters container sewage polluted pools and even in brackish water Adul mostly feed on cattle and are found both in houses an cattle sheds

A vagus Donitz 1902 It is found in Assam Benga Bihar Bombay Deccan Madhya Pradesh Chhota Nagpu Gujerat Hyderabad Konkan Madras East and West Coa Malabar Mysore State and Orissa It has been report infected in nature from Pattukkottai S India (one glar infection out of 6874 dissected Russell and Rao *loc cit*) an from Assam (2 gland infections out of 10452 dissecte Strickland *et al* 1933) It breeds in small pools and found in houses and cattle sheds but feeds mostly animals

Th following additional spec s of anophelin s have been reported India but natural infection in them have not yet been reported —
A a tken A a tkeni var bengalen s A annandal A annand var interruptus A ba b ostris A ba birostris var ah im A baran is A cl vige var habibe A culiciformis A dthali A gigas A gi var ba leyi A g gas var refulans A gigas var simlensis A hyrcan A hyr anus var nigerrimus A insulaeflorum A ja nesi A l ndesa A l desayi var nilgiricus A maj di A moghulensis A mu color A p njaurensis A se gent A s ntoni A 1 s llatus A th bo A tu khud and *A umbrosus*

Th following are known vectors in the neighbouring countries

Burma	*A minimus A j yporien is var candid ensi sunda cus A annularis*
Malaya	*A sunda us A maculatus A umb osus*
Java	*A sunda cus A aconitus*
Sumatra	*A sundaicus A aconitus A hy canus var sinen A leucosphyrus A umbrosus A koch A subp ct A barbirostris*
Indo-China and Eastern and Southern China	*A m nimus A pryporien is var cand d ensis A h ca us var s nen is A su da cus A subpict indefinitus*

REFERENCES

Aitre J R (1903) *Ind Med Ga* 38 246-249

Adisubramaniam T S and Vedamanikkam J C (1943) *J M Inst Ind* 3 113 116

CHAPTER IV

SOME IMPORTANT FACTORS RELATING TO THE PREVALENCE OF MALARIA

Continued existence of malaria depends on a variety of factors some of them being —

- Distribution and prevalence of malaria
- Climate
- Plant life and malaria
- Immunity—race age sex and occupation
- Man made malaria

DISTRIBUTION AND PREVALENCE

Malaria is a focal global disease and extends to 60 N latitude in Russia and 40 S in Argentine as high as 9000 feet in Quito in Ecuador and as low as 1300 feet below the sea in the Dead Sea The distribution of malaria in the world is usually divided in three zones viz the temperate zone (40 N to about 60°N with patchy distribution of malaria and benign tertian as predominant species and with little malaria in the corresponding zone of the southern hemisphere) the subtropical zone (Tropic of Cancer to 40 N and corresponding zone of the southern hemisphere with autumnal epidemics and malignant tertian as the common infection and benign tertian frequent in the malarious regions) and the tropical zone (Tropic of Cancer to Tropic of Capricorn with malignant tertian as predominating parasite wide distribution of the *disease and in areas near the equator throughout the year)* The Indian sub-continent with its greatest length north to south about 2000 miles and its greatest breadth from east to west about 1500 miles shows a very great variation of physical features In the wide range of its latitude and longitude it offers an Arctic climate in the snow-clad areas 15000 feet up in the Himalayas and a great belt of temperate and tropical climate lower down The winter isotherm at the foot of the Himalayas is about 50 F The

plains of the north have extremes of climate bitterly cold in winter and blistering hot in summer The south remains hot throughout the year (winter 75 F summer 82 F) Rainfall varies from place to place from the world s highest record of about 430 inches at Cherrapunji in Assam to less than 6 inches in a year in Rajputana and the west The greater part of the Punjab (pre partition) contains rich alluvial soil brought down by the rivers while the southern tableland is composed of rocks with a thin layer of soil The western parts of India and Malwa have black cotton soil The Assam Valley between the Burma Hills and the Himalayas is 50 miles wide and 300 miles long and is full of detritus to a depth of about 3 miles The melting snow from the Himalayas gives rise to a 7 mile wide river the Brahmaputra Heat and moisture help thick forests like those of the Sunderbans to flourish at the mouth of the Ganges whereas heat with no moisture pervades the deserts in Rajputana and the west Depending on the fertility of the soil the population in the Indo Gangetic plain and on the Western and Eastern Coasts is very thick but in Sind and Rajputana sparse These widely different conditions of soil and climate varying from snow bound rocks to warm well watered and fertile valleys persuade men to sow different crops by different methods to undertake different irrigation and engineering projects They provide breeding places for different species of anopheline mosquitoes

Knowles *et al* (1930) observe that zoographically the Indian sub-continent differs from other malarious countries at all points except as regards the North East Frontier The Persian desert cuts it off from the malarial region of Mesopotamia in the west the Pamirs separate it on the north west from the malaria of the lower Oxus Valley whilst to the north the Himalayas and the immense tableland of Tibet at an elevation inhibitory to the disease separate it from the malaria that is known to occur in Siberia With the exception of the North East Frontier the ocean bounds the remainder It must have been through the corridor of the Brahmaputra Yangtse that malaria entered the country Kashmir which is the farthest point from the entrance is comparatively malaria free *Plasmodium malariae* the

low humidity and at low temperatures they do not bite They can however, live for long periods with infected blood meal and can convey the disease when the temperature rises again except when they are in a state of complete hibernation With high humidity the mosquitoes may not only live to allow the parasite cycle to be completed but to transmit the infection to several persons The minimum temperatures for continuous development of *P malariæ* *P vivax* and *P falciparum* are generally 16 5 C 17 5 C and 18 C respectively

PLANT LIFE AND MALARIA

Plants provide under certain circumstances protection and food to mosquito larvæ In *jheels* tanks ponds and numerous collections of water a careful observer will find four different zones of vegetation A bottom zone (vital layer) of silt with microscopic plants putrefaction bacteria sulphur bacteria iron bacteria unicellular plants (the Diatoms) and blue green algæ the second zone of flowering aquatic plants rooted to the bottom layer (viz ribbon shaped green leaves with underground trailing stems of the *Vallisneria spiralis*) The third zone is composed of floating and submerged vegetation The commonest water plants in India are the *Hydrilla verticillata* *Ceratophyllum demersum* *Myriophyllum tuberculatum* *Lagarosiphon Roxburghii* *Najas indica* *N foveolata* *Utricularia flexuosa* *U stellaris* and others Finally the fourth zone is composed of numerous floating and amphibious plants The floating vegetation may be non flowering water plants or minute flowering plants like Wolffia Lemna and Azolla (which incidentally serve as food for fish) But often these non flowering or minute flowering plants are replaced by larger plants such as *Pistia stratiotes* *Salvinia cucullata* and water hyacinth These large plants provide support to various types of amphibious vegetation like *Jussiæa repens* *Ipomœa reptans* *Enhydra fluctuans* and *Hygrorhiza aristata* etc The vegetation if allowed to grow unchecked forms a dense canopy on the surface of the water The activity of the putrefying bacteria and Schizomycetes of the vital layer converts rotten vegetation

and organic matter into nutrient salts and provides in exhaustible food for the growth of plants Dense vegetation consequently develops and puts an end to the life of various fresh aquatic fauna like cyclops copepods rotifers para mecium amoeba and other lower members of the animal kingdom (These smaller members form food for crusta ceans fish etc) The adverse effect on the various fauna is mainly due to absence of light and oxygen and the pre sence of gases The association of various types of vegeta tion with breeding places of various species of mosquitoes has not yet been thoroughly investigated but there is no doubt that further researches will soon establish intimate relation of various species of mosquito with different types of aquatic growth Reference has been made (while dis cussing bionomics of the different species) to the fact that breeding places of *A philippinensis* larvæ are associated with *Hydrilla verticillata Ceretophyllum demersum Utri cularia Najas* and non holding masses of filamentous green algæ Duckweed water hyacinth blue green algæ such as *Anabæna Oscillatoria Mycrocystis ærugenosa* and *Euglena* and other flagellates appear to render the collec tions of water unsuitable for breeding places of *A philip-pinensis* larvæ *A sundaicus* is often associated with vegetation such as algæ (*Enteromorpha Cladophora Cynophyceæ*) *Oscillatoria germinata Lyngbya Confer voides Oedogonium* and dead aquatic vegetation (*Poto mogenton pectinatus Halophila ovata* and the well known brackish water blue green algæ *Lyngbya æstuarii*) *A annularis* like *A philippinensis* is found associated with floating vegetation composed of *Hydrilla verticillata Cera tophyllum demersum* and algæ growth mainly of spiro-gyra *A ramsayi* is found occurring with *Pistia stratiotes* (Biswas 1940 1944 1945)

IMMUNITY

It is common experience that some patients suffer ing from malaria spontaneously recover without any form of specific treatment Spontaneous recovery of the patient infected with malaria parasites points to a very efficient defence mechanism in the body Experiments on rhesus

low humidity and at low temperatures they do not l They can, however live for long periods with infe blood meal and can convey the disease when the temp ture rises again except when they are in a state of comp hibernation With high humidity the mosquitoes may *only live to* allow *the parasite cycle to be completed* to transmit the infection to several persons The minim temperatures for continuous development of *P mala* *P vivax* and *P falciparum* are generally 16 5 C 17 and 18 C respectively

PLANT LIFE AND MALARIA

Plants provide under certain circumstances pr tion and *food to mosquito larvæ* In *jheels* ta ponds and numerous collections of water, a ca observer will find four different zones of vegeta A bottom zone (vital layer) of silt with microscopic pl putrefaction bacteria, sulphur bacteria iron bact unicellular plants (the Diatoms) and blue green algæ second zone of flowering aquatic plants rooted to the bo layer (viz ribbon shaped green leaves with undergr trailing stems of the *Vallisneria spiralis*) The third is composed of floating and submerged vegetation commonest water plants in India are the *Hydrilla ver lata Ceratophyllum demersum Myriophyllum tuber tum Lagarosiphon Roxburghii Najas indica N foveo Utricularia flexuosa U stellaris* and others Finally fourth zone is composed of numerous floating and am bious plants The floating vegetation may be non flow water plants or minute flowering plants like Wolffia Le and Azolla (which incidentally serve as food for fish) often these non flowering or minute flowering plants replaced by larger plants such as *Pistia stratiotes Sal cucullata* and water hyacinth These large plants pro support to various types of amphibious vegetation like *sæa repens Ipomœa reptans Enhydra fluctuans Hygrorhiza aristata* etc The vegetation if allowed to unchecked forms a dense canopy on the surfac the water The activity of the putrefying bacteria Schizomycetes of the vital layer converts rotten veget

and organic matter into nutrient salts and provides in exhaustible food for the growth of plants · Dense vegetation consequently develops and puts an end to the life of various fresh aquatic fauna like cyclops copepods rotifers para mecium amoeba and other lower members of the animal kingdom (These smaller members form food for crusta ceans fish etc) The adverse effect on the various fauna is mainly due to absence of light and oxygen and the pre sence of gases The association of various types of vegeta tion with breeding places of various species of mosquitoes has not yet been thoroughly investigated but there is no doubt that further researches will soon establish intimate relation of various species of mosquito with different types of aquatic growth Reference has been made (while dis-cussing bionomics of the different species) to the fact that breeding places of *A philippinensis* larvæ are associated with *Hydrilla verticillata Ceretophyllum demersum Utri cularia Najas* and non holding masses of filamentous green algæ Duckweed water hyacinth blue green algæ such as *Anabæna Oscillatoria Mycrocystis ærugenosa* and *Euglena* and other flagellates appear to render the collec-tions of water unsuitable for breeding places of *A philip-pinensis* larvæ *A sundaicus* is often associated with vegetation such as algæ (*Enteromorpha Cladophora Cynophyceæ*) *Oscillatoria germinata Lyngbya Confer voides Oedogonium* and dead aquatic vegetation (*Poto-mogenton pectinatus Halophila ovata* and the well known brackish water blue green algæ *Lyngbya æstuarii*) *A annularis* like *A philippinensis* is found associated with floating vegetation composed of *Hydrilla verticillata Cera tophyllum demersum* and algæ growth mainly of spiro-gyra *A ramsayi* is found occurring with *Pistia stratiotes* (Biswas 1940 1944 1945)

IMMUNITY

It is common experience that some patients suffer ing from malaria spontaneously recover without any form of specific treatment Spontaneous recovery of the patient infected with malaria parasites points to a very efficient defence mechanism in the body Experiments on rhesus

low humidity and at low temperatures they do not bite They can however live for long periods with infected blood meal and can convey the disease when the tempera ture rises again except when they are in a state of complete hibernation With high humidity the mosquitoes may not only live to allow the parasite cycle to be completed but to transmit the infection to several persons The minimum temperatures for continuous development of *P malariæ* *P vivax* and *P falciparum* are generally 16 5°C 17 5 C and 18 C respectively

PLANT LIFE AND MALARIA

Plants provide under certain circumstances protec tion and food to mosquito larvæ In *jheels* tanks ponds and numerous collections of water, a careful observer will find four different zones of vegetation A bottom zone (vital layer) of silt with microscopic plants putrefaction bacteria sulphur bacteria iron bacteria unicellular plants (the Diatoms) and blue-green algæ the second zone of flowering aquatic plants rooted to the bottom layer (viz ribbon shaped green leaves with underground trailing stems of the *Vallisneria spiralis*) The third zone is composed of floating and submerged vegetation The commonest water plants in India are the *Hydrilla vertical lata Ceratophyllum demersum Myriophyllum tubercula tum Lagarosiphon Roxburghii Najas indica N foveolata Utricularia flexuosa U stellaris* and others Finally the fourth zone is composed of numerous floating and amphi bious plants The floating vegetation may be non flowering water plants or minute flowering plants like Wolffia Lemna and Azolla (which incidentally serve as food for fish) But often these non flowering or minute flowering plants are replaced by larger plants such as *Pistia stratiotes Salvinia cucullata* and water hyacinth These large plants provide support to various types of amphibious vegetation like *Jussiæa repens Ipomœa reptans Enhydra fluctuans* and *Hygrorhiza aristata* etc The vegetation if allowed to grow unchecked forms a dense canopy on the surface of the water The activity of the putrefying bacteria and Schizomycetes of the vital layer converts rotten vegetation

other human beings by about the end of third week A few cases of malaria thus occur by the end of the fifth week The persons now infected produce large number of game tocytes by the end of the sixth week and infect many mosquitoes The infected female anophelines in their turn are able to infect many persons by the end of the eighth week Thus by the end of the tenth week from the initial laying of eggs an outbreak of large number of malaria cases occurs The subsequent events depend on the conditions favourable for propagation and longevity of the carrier species communal immunity and facilities for the spread of infection

From the above very brief account the complexity of the malaria problem is obvious The principal factors not only differ between districts of the same State but also in rural and urban localities of the same district The same species of mosquito may behave differently under different conditions viz *A maculatus* a dangerous vector in Malaya is relatively innocuous in India *A philippinensis* is found in human habitations in Bengal but rests in cattle sheds in Assam It is probable that these are biologically distinct races of the same species Strains of malaria para sites show a wide variation A community may be rela tively immune to a particular strain of a species of malaria parasite and show a very low incidence of malaria but a foreign strain may precipitate an epidemic if circumstances are favourable for the spread of infection It is essential to study and make a survey of each locality before attributing incidence of malaria to any of the factors referred to above Different species of anophelines may require different control measures It is easy to understand how immense harm can be done by putting embankments railways roads drains and barrages in places where from malaria point of view they are not desirable by selecting a site for habitation with out a previous malaria survey of the locality by leaving borrow pits and brickfields unattended thereby increasing breeding places for mosquitoes by faulty methods of irriga tion by injudicious house construction by imperfect drain age or sewage system and by uncontrolled aggregation of a large population

natural surroundings were carried out The hill section of the Bengal Assam Railway is an outstanding example where jungles were cut down and graves took their places It is stated that one man died for every sleeper laid

Malaria Forecast

For malaria to spread there must be infected persons with sufficient number of malaria parasites female anophe line mosquitoes with facilities to breed and bite human beings and the presence of susceptible individuals Epide mics occur when a large number of non immune persons enter into a locality or if a foreign strain of malaria parasite is introduced into a community In areas where reinocula tion practically throughout the year does not take place seasonal epidemics occur if there is an increase of the infec tive vector with facilities for spread of infection The Punjab (pre partition) Health Department used to forecast the probable incidence of malaria every year in the begin ning of September The method of forecasting was based on the hypothesis that malaria epidemics occur due to the loss of equilibrium between infection and immunity consequently involving the consideration of humidity spleen rates epidemic potential and economic factors An excessive rainfall in July and August extensive floods a relatively high epidemic potential factor (above 60) a low spleen rate in June and a famine or relatively higher price during the preceding year give warning of the onset of an epidemic Such forecasts based on the above mentioned factors, have proved of immense value to warn in good time the areas likely to be affected (Butt 1944)

Epidemics

The sequence of events in epidemics may be sum marised as follows The surviving malaria carrying mos quitoes lay eggs By the end of a week or ten days adult mosquitoes emerge They may take blood feed from human beings who are gametocyte carriers The number of such carriers however is low at this stage The few female anopheline with infected blood feed are able to infect

CHAPTER V

ELIMINATION OF BREEDING PLACES

Effective anti malaria measures include measures to prevent infective species of mosquitoes from breeding offensive campaign against mosquitoes in all stages of development careful defensive action to protect human beings from the bite of mosquito and administration of drugs to kill the parasite injected into the system by mosquitoes that survive offensive action and penetrate defences

Man made breeding places in fields and firetins borrow pits and brickfields tubs and tanks roads railways and the like and those in nature like swamps seepages etc can be readily eliminated by simply ensuring adequate drainage of water and by preventing water from collecting

SWAMPS AND SEEPAGES

Rain water either flows down the earth as surface water and runs in streams rivers and ultimately into the sea or percolates into the earth emerging lower down as seepages and swamps Usually some of it runs as surface water and the remainder sinks into the earth Such collections of water can be got rid of by a well planned system of drainage The drainage may be open on the surface or subsoil leading from subsidiary drains to the main drain

Surface or open drains should be narrow with sides free from vegetation and with adequate fall and depth and rounded bottom Subsidiary drains or tributaries should join it at an acute angle In swamps they can be made to run parallel or in herring bone arrangement In foot hills it is best to mark out soon after a shower of rain areas of highest springs and seepages and then to dig a contour drain of adequate size (usually 4 deep 6 wide at the top and 1 at the bottom) at right angles to the flow of water down the foot hill Excavated earth should be thrown at least 10 behind the drain Drains have been excavated in the U.S A and Palestine by laying dynamite charges 1½ feet apart in holes (Svensson) This method has been

The infectivity of the anopheline and the factors discussed above alone do not always explain the abnormally high incidence of the disease All possible associated factors have therefore to be investigated For example overlapping of two species like *A leucosphyrus* and *A minimus* in Assam and Kabaw Valley lead to serious results One specie may appear for a short period but can commence transmission early raising the gametocyte rate in the local population, consequently when the other specie appears it starts intensive transmission

REFERENCES

BISWAS K (1940) *Science and Culture* 11, 327 330
Idem (1944) *Ibid* 9, 426-428
Idem (1945) *Personnel communication*
BUTT A H (1944) *Personnel communication*
KNOWLES R SENIOR WHITE R AND DAS GUPTA B M (1930) *Ind J Med Res Special Memoirs* 18, 138 139
TALIAFERRO W H AND MULLIGAN H W (1937) *Ind Med Res Memoir No 29* 118

increasing the outlet helps to get rid of the collection of water It is however emphasised that it is not necessary to drain all pools and swamps if larvæ are not found breeding in them Injudicious construction of drains in areas where the vector mosquito breeds in running streams is obviously dangerous In some areas with moderate monsoon rainfall bunds are put so that rain water is directed to a single Lido or depression

BORROW PITS AND BRICKFIELDS

It is a common practice to dig earth for the construction of roads railways canals embankments and in brick kiln areas leaving behind vast pits below the drainage level If the earth is so excavated as to leave an even slope no water will collect Where such a procedure is not possible the pits can be dug in series connected with each other and sloped so that no water is able to accumulate Partial filling may be required in places to ensure a proper gradient A note of warning may again be given that draining of the pits by connecting them can lead to dangerous breeding places in areas where the infective vector breeds in drains with grassy edges and running water In such areas it may be possible to break the impervious stratum and make vertical drains Filling in of pits is ideal but the cost is often prohibitive

QUARRIES

Quarries leave numerous depressions Quarrying should be done vertically so that the face is only very slightly undermined (preferably not at all undermined) leaving no chance for water to collect

HOLES IN TREES ROCKS AND SAND

Holes in trees and rocks require filling with earth Crab holes and the like may be filled with Paris green sand or earth

FIELDS

Fields with wet cultivation may be associated (especially in the case of irrigation channels in the rice fields) with malaria Fields flooded with silt are less liable to

found not only labour saving but also quick The drains may be built with or without lining *Pukka* cement or *stone is not absolutely* necessary for more than 3′ above the normal flowing water level in the drain If the storm water drain is intended to carry sullage in addition to rain water the whole drain should be lined and provided with central cunette for carrying the *perennial flow giving the least breeding surface* The un lined drains often get damaged and require constant atten tion in cleaning and grading These drains can also be made of circular pipes 4 to 12 in diameter 1 to 2 long or open concrete inverts can be laid and covered with gravel *and earth and thus prevent rain from damaging the top* The laying out of sub soil drains requires skilled labour Initial cost is high but recurring expense is low They can be easily supervised

Faggot or fascine drains have been successfully used *in Malaya and Africa (Watson, 1942) on a large scale* Drains are filled with lengths of cut bamboos complete with leaves as they are cut from the trees In a mine in Africa these covered drains were made in 1932 and were found working well for long periods up to 1939 without any repairs or upkeep Stone packed drains can also be made They often require renewal Sub drainage has been used in Kangra Valley and has turned a highly malarious water logged area into a cattle grazing ground free from malaria (Raina 1946) All that was done was to dig *kutcha* surface drains they were covered with flat stones and earth and grass was planted on top

At times it is difficult to drain collections of water lying over an impervious stratum In some cases a pit can be dug and a shaft driven vertically down through the impermeable stratum Stones are packed round the shaft These vertical drains in selected suitable places effectively accelerate percolation of water The number of such verti cal drains depends on the size of the area *to be drained* In a few cases all that is required is to submerge or to flood the swamps by putting weir lower down These can be sluiced or larvæ can be dealt with by a suitable antilarval method Invariably the rule of decreasing the inlet or

increasing the outlet helps to get rid of the collection of water It is however emphasised that it is not necessary to drain all pools and swamps if larvæ are not found breed ing in them Injudicious construction of drains in areas where the vector mosquito breeds in running streams is obviously dangerous In some areas with moderate mon soon rainfall bunds are put so that rain water is directed to a single Lido or depression

BORROW PITS AND BRICKFIELDS

It is a common practice to dig earth for the construction of roads railways canals embankments and in brick kiln areas leaving behind vast pits below the drainage level If the earth is so excavated as to leave an even slope no water will collect Where such a procedure is not possible the pits can be dug in series connected with each other and sloped so that no water is able to accumulate Partial filling may be required in places to ensure a proper gradient A note of warning may again be given that draining of the pits by connecting them can lead to dangerous breeding places in areas where the infective vector breeds in drains with grassy edges and running water In such areas it may be possible to break the impervious stratum and make vertical drains Filling in of pits is ideal but the cost is often prohibitive

QUARRIES

Quarries leave numerous depressions Quarrying should be done vertically so that the face is only very slight ly undermined (preferably not at all undermined) leaving no chance for water to collect

HOLES IN TREES ROCKS AND SAND

Holes in trees and rocks require filling with earth Crab holes and the like may be filled with Paris green sand or earth

FIELDS

Fields with wet cultivation may be associated (espe cially in the case of irrigation channels in the rice fields) with malaria Fields flooded with silt are less liable to

breed mosquitoes The incidence of malaria may depend on the methods of irrigation Perennial irrigation channels from canals give rise to seepages and water logging and inundation irrigation leaves pools after the flood subsides Counter drainage good maintenance of channels and sluice gates and restrictions on water supply can reduce the number of breeding places considerably Channel banks should be protected if necessary by fencing Disused water courses should be filled in as far as possible Intermittent drying of fields reported by Russell has proved a great success in South India where rice fields are kept dried for two days in the week Kalandadze and Sagatelova (1944) have drawn attention to the fact that anopheline eggs or larvæ may not die unless drying is absolutely complete as in the presence of slight moisture the eggs especially anopheline eggs can survive for over a week Intermittent flooding has not only reduced the number of breeding places but has in many cases improved the yield of crops

Pipes

Piped water supply for irrigation or domestic use requires constant supervision of hydrants storage tanks and stand pipes Hydrants and sluice valves should not leak A concrete platform with a proper drain to allow the water to run off should be provided round hydrants and stand pipes

Wells tanks and swimming pools

Wells can be rendered innocuous by introducing larvivorous fish or sealing the top with concrete and lifting the water by means of a pump A mosquito-proof cast iron inspection door can be incorporated in the concrete seal

All water cisterns similarly require well fitting lids and the side holes must be closed in all cases to prevent entry of mosquitoes

Water in the swimming pools etc should be changed weekly

Drains

Domestic and sewage drains require special attention

As far as possible they should not cross the road or neighbouring houses They can be made of semi-cylindrical glazed pipes or concrete halves The terminal drains can be rendered mosquito-proof by covering the last 75 with concrete If the connection is made with a pipe of 6 diameter a 12 feet off set effectively prevents the entering of mosquitoes and consequently prevents breeding The same principle holds good for ventilation shafts Ventilation shafts of dimensions of more than 6 diameter will require mosquito-proofing The main drains are usually 8 wide at the top 2 at the bottom and 5 deep

SEWAGE DISPOSAL

Sewage disposal (except when in the sea or large rivers) requires constant supervision *A stephensi* has been reported to breed in sewage contaminated water

ROADS AND RAILWAYS

Embankments put across natural drainage lead to the rise of subsoil water and obstruct the flow of storm water and thus lead to numerous collections of water All embankments across the natural line of drainage should be avoided Drains should be provided on either side of the embankments so that any water likely to collect is drained off In road and railway construction the problem of embankments requires serious consideration A sufficient number of bridges and culverts with inverts placed at correct level can prevent collections of water Collections of water on roads built under bridges may require pumping out

DAMS AND BARRAGES

Dams and barrages often give rise to a number of breeding places Drainage of overflow prevention of leaks and provision for rapidly lowering the level of water in impounded waters help considerably in reducing mosquito breeding

JUNGLE CLEARANCE

Indiscriminate clearing of jungle is dangerou Bionomics of the mosquitoes hould be studied

breed mosquitoes The incidence of malaria may depend on the methods of irrigation Perennial irrigation channels from canals give rise to seepages and water logging and inundation irrigation leaves pools after the flood subsides Counter drainage good maintenance of channels and sluice gates and restrictions on water supply can reduce the number of breeding places considerably Channel banks should be protected if necessary by fencing Disused water courses should be filled in as far as possible Intermittent drying of fields reported by Russell has proved a great success in South India where rice fields are kept dried for two days in the week *Kalandadze and Sagatelova (1944)* have drawn attention to the fact that anopheline eggs or larvæ may not die unless drying is absolutely complete as in the presence of slight moisture the eggs especially anopheline eggs can survive for over a week Intermittent flooding has not only reduced the number of breeding places but has in many cases improved the yield of crops

PIPES

Piped water supply for irrigation or domestic use requires constant supervision of hydrants storage tanks and stand pipes Hydrants and sluice valves should not leak A concrete platform with a proper drain to allow the water to run off should be provided round hydrants and stand pipes

WELLS TANKS AND SWIMMING POOLS

Wells can be rendered innocuous by introducing *larvivorous fish or sealing the top* with concrete and lifting the water by means of a pump A mosquito-proof cast iron inspection door can be incorporated in the concrete seal

All water cisterns similarly require well fitting lids and the side holes must be closed in all cases to prevent entry of mosquitoes

Water in the swimming pools etc should be changed weekly

DRAINS

Domestic and sewage drains require special attention

As far as possible they should not cross the road or neighbouring houses They can be made of semi-cylindrical glazed pipes or concrete halves The terminal drains can be rendered mosquito-proof by covering the last 75' with concrete If the connection is made with a pipe of 6 diameter a 12 feet off set effectively prevents the entering of mosquitoes and consequently prevents breeding The same principle holds good for ventilation shafts Ventilation shafts of dimensions of more than 6 diameter will require mosquito proofing The main drains are usually 8 wide at the top 2 at the bottom and 5 deep

Sewage disposal

Sewage disposal (except when in the sea or large rivers) requires constant supervision *A stephensi* has been reported to breed in sewage contaminated water

Roads and railways

Embankments put across natural drainage lead to the rise of subsoil water and obstruct the flow of storm water and thus lead to numerous collections of water All embankments across the natural line of drainage should be avoided Drains should be provided on either side of the embankments so that any water likely to collect is drained off In road and railway construction the problem of embankments requires serious consideration A sufficient number of bridges and culverts with inverts placed at correct level can prevent collections of water Collections of water on roads built under bridges may require pumping out

Dams and barrages

Dams and barrages often give rise to a number of breeding places Drainage of overflow prevention of leaks and provision for rapidly lowering the level of water in impounded waters help considerably in reducing mosquito breeding

Jungle clearance

Indiscriminate clearing of jungle is dangerous Bionomics of the mosquitoes should be studied

DRY DAY

There are numerous breeding places that can be elimi nated by every individual Pots and pans tins and bottles should not be carelessly thrown away Small collections of water in pits and pools in and around houses should be filled or drained It should form a rule in every home to empty all vessels containing water like *chatties* buckets etc at least once a week In public institutions like schools offices and municipalities a *dry day* every week should be observed The object of this measure is that on one day in the week every place is kept completely dry for a short time A thorough inspection of the whole area within fixed hours should be carried out to ensure that no collection of water has been overlooked

REFERENCES

COVELL G (1941) *Anti mosquito measures* with special reference to India Health Bulletin No 11 Malaria Bureau No 3 Manager Publication Delhi

KALANDADZE L P AND SAGATELOVA (1944) *Trop Dis Bull* 41 916

RAINA B L (1946) *Anti malaria measures Yol Kangra Valley* (not published)

SVENSSON R *A handbook of malaria control* Shell Book Oil Companies

WATSON M (1942) *Some Emergency Anti Malarial Measures* Ross Institute Industrial Advisory Committee 6

CHAPTER VI

ANTI LARVAL MEASURES

Before starting anti larval measures it is necessary to study the local breeding places the ecology of the mosquitoes particularly the vector species Much time labour and money can be saved if those places only are treated which breed mosquitoes especially the vector species It may be added that in an area other species of mosquito though not responsible for carrying malaria have great nuisance value especially during the spring in the plains and their breeding should also be controlled The areas to be controlled will depend on various factors including species of anopheline mosquito the nature of the breeding places the prevailing wind distance of human habitation from the breeding place etc It may be stated as a general rule that control over an area up to at least half a mile round an inhabited locality gives satisfactory results Ribbands (1944) however points out that the risk of getting infection is negligible if five miles and is small if two miles intervene between the camp and any infected locality Risk of getting infection however increases if there are breeding places between the infected area and the area to be protected or the number of residents in the locality is small Raevsky and his colleagues (1944) have reduced the risk by putting cowsheds and animal houses on the leeward side between the breeding places and human habitation (mosquitoes start feeding on cattle instead of men) The animal sheds are put not less than 200 meters from the human habitation (piggeries 250 m) The animal houses should be separated from each other by following gaps byres 50 meters pigsties 45 meters sheep pens 50 meters apart with doors on the leeward side There should be vegetation between the barrier and human dwelling Cattle must return from grazing not later than half an hour before sunset

Anti larval measures wherever feasible should be permanent Temporary measures invariably prove

DRY DAY

There are numerous breeding places that can be elimi nated by every individual Pots and pans tins and bottles should not be carelessly thrown away Small collections of water in pits and pools in and around houses should be filled or drained It should form a rule in every home to empty all vessels containing water like *chatties* buckets etc at least once a week In public institutions like schools offices and municipalities a *dry day* every week should be observed The object of this measure is that on one day in the week every place is kept completely dry for a short time A thorough inspection of the whole area within fixed hours should be carried out to ensure that no collection of water has been overlooked

REFERENCES

COVELL G (1941) *Anti mosquito measures* with special reference to India Health Bulletin No 11 Malaria Bureau No 3 Manager Publication Delhi

KALANDADZE L P AND SAGATELOVA (1944) *Trop Dis Bull* 41 916

RAINA B L (1946) *Anti malaria measures Yol Kangra Valley* (not published)

SVENSSON R *A handbook of malaria control* Shell Book Oil Companies

WATSON M (1942) *Some Emergency Anti Malarial Measures* Ross Institute Industrial Advisory Committee 6

Chapter VI

ANTI LARVAL MEASURES

Before starting anti larval measures it is necessary to study the local breeding places the ecology of the mosquitoes particularly the vector species Much time labour and money can be saved if those places only are treated which breed mosquitoes especially the vector species It may be added that in an area other species of mosquito though not responsible for carrying malaria have great nuisance value especially during the spring in the plains and their breeding should also be controlled The areas to be controlled will depend on various factors including species of anopheline mosquito the nature of the breeding places the prevailing wind distance of human habitation from the breeding place etc It may be stated as a general rule that control over an area up to at least half a mile round an inhabited locality gives satisfactory results Ribbands (1944) however points out that the risk of getting infection is negligible if five miles and is small if two miles intervene between the camp and any infected locality Risk of getting infection however increases if there are breeding places between the infected area and the area to be protected or the number of residents in the locality is small Raevsky and his colleagues (1944) have reduced the risk by putting cowsheds and animal houses on the leeward side between the breeding places and human habitation (mosquitoes start feeding on cattle instead of men) The animal sheds are put not less than 200 meters from the human habitation (piggeries 250 m) The animal houses should be separated from each other by following gaps byres 50 meters pigsties 45 meters sheep pens 50 meters apart with doors on the leeward side There should be vegetation between the barrier and human dwelling Cattle must return from grazing not later than half an hour before sunset

Anti larval measures wherever feasible should be permanent Temporary measures invariably prove

expensive in the long run due to the recurrin expenditure

Temporary measures however, will be required i many places during the construction of works collection o large number of people for a short period and during the interim period when permanent measures are being made

Anti larval measures can also be naturalistic o chemical

NATURALISTIC

Naturalistic or biological measures aim at so altering the natural conditions as to render the place unsuitable for breeding The following methods have been successfully used against larvæ of different species

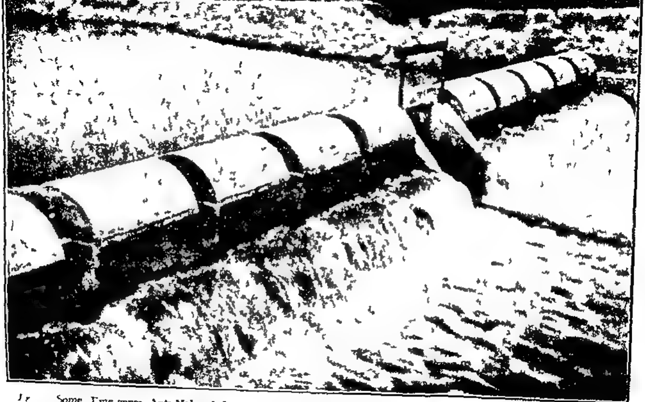
Sluicing flooding silting agitating the surface of water changing its level etc
Deep shading
Pollution
Changing the salt content
Alteration of food supply
Larvivorous fish

Sluicing The sluicing is only an imitation of nature s method of flushing down the larvæ water of a stream is dammed and released at intervals by either hand-operated sluice gates or by automatic siphons Sluice gates were first used by Graham at Lucknow in 1913 in the river Gumti They were popularised as malaria control measure by Prof K B Williamson who used them between 1930 32 in Malaya against *A maculatus* By 1937 about 200 streams along 15 miles of hills in Penang were being successfully flushed By the force and disturbance of water larvæ are washed down and stranded In some cases eggs and pupæ drift to the banks lower down and require further treatment Macdonald designed an automatic siphon incorporating DeVilliers siphon with full flush of 475 gallons per minute at a cost of Rs 25/ siphon The main parts of DeVilliers siphon ar oil drum on three concrete blocks a main

[illegible] Siphon on an estate in Malaya

F [illegible] Some Emergency Anti-Malarial Measures [illegible]
[illegible] of Tropical Hygiene

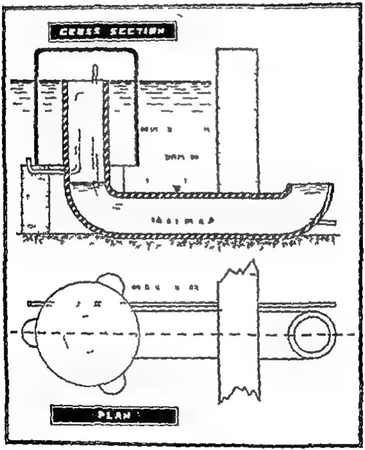
[Face page 47]



Fr Some Emergency Anti Malarial Measures by Sir Malcolm Watson Ross Institute of Tropical Hygiene

of concrete or earthenware pipe which runs under the dam and a secondary siphon consisting of ¾ galvanised iron pipe

AUTOMATIC FLUSHING SIPHON DE VILLIERS TYPE



From Some Emergency Anti Malarial Measures by Sir Malcolm Watson Ross Institute of Tropical Hygiene

In small streams earth dams with one or more oil drums the ends of which had been removed to form an opening through the dam for releasing the flush have been used in South India The upper end of the drum is kept closed by a sheet of wood until the dam is full then the wood is removed by hand and the stream is flushed Various other sluice gates (like drums fixed eccentrically so that they tilt immediately they are filled up with water and resume vertical position when empty) have been improvised at a very low cost (Watson 1942)

The pipeless siphon used in Tea Estates is a great improvement The principle on which they work is that when the water rises in the catchment area it flows over the weir and falls into the sealing trough below at the outflow taking air with it When water falls in the trough some of these bubbles come up on the outside of the trough thereby causing a partial vacuum inside the siphon This unequal pressure between the outside and the inside of the siphon starts the flow of water expelling all the air inside the siphon When the water level in the catchment area falls sufficiently low to admit air to enter at the inlet the vacuum is removed and the siphon immediately shuts off until the water level rises and the cycle again commences Atmospheric balancing valves are placed at the highest point of the siphon so that by opening these valves the siphon may be stopped at any stage of working (Ramsay 1944) These siphons may be of any size and shape depending on the quantity of water to be released Water released must not exceed the amount normally carried during floods

Like all measures sluicing has its limitations Site and distance between the series of sluice gates in a stream will vary with different places

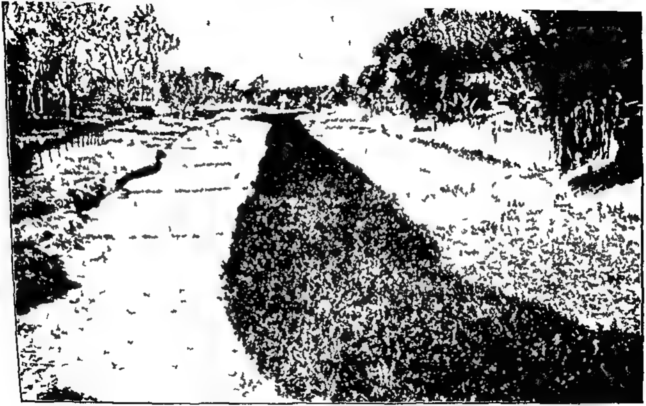
Flooding Floods with silty water have been noticed to reduce the incidence of malaria Rise of water level in Bengal is a good example Sinha (1940) gives seven reasons in favour of a flood flush scheme viz it maintains during the rainy season flow of silty water in the drains ditches water channels pools borrow pits and low lying areas as a result of which mosquito breeding is easily and

Automatic anti-malarial sluice in a Malaya garden. The tipper is hinged on a wooden roller like a ship's rudder. Two sheets of rubber make it water-tight. Stones in the box balance the tipper so that it discharges at the desired height in the dam.

From "Some Emergency Anti-Malarial Measures," by Sir Malcolm Watson, Ross Institute of Tropical Hygiene.

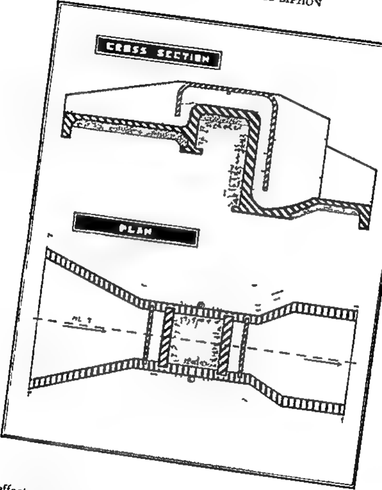
[To face page 48]

To face page 49]



F o n Som Eme g n y Ant Mal rial Measu by S r Malcolm Watson Ro In t tute f Tr p cal Hyg

AUTOMATIC PIPELESS SIPHON



effectively checked The low lying areas small pits and depressions are gradually filled up by silt deposit It helps local drainage by discharging water when the tide is low It feeds numerous tanks and ponds with good river water

Widely divergent views are held regarding the utility of indigenous fish * Hacket pointed out that the local fish after centuries reach a balance regarding their natural enemies and the number cannot be artificially increased and maintained at an abnormally high level of density whereas if exotic fish can be acclimatised they will proliferate and maintain their number at abnormally high level On the other hand Fry Hora Prasad Sweetnam and Meyers advocate the use of indigenous fish and condemn the use of exotic fish on biological grounds There is enough evidence to believe that some indigenous fish like Panchax Aplocheilus Aphanous and Schizothorax pro gastus are equally larvivorous as exotic genera

Larvivorous fish have their limitations In temporary collections of water or in places used as permanent fisheries their use is not recommended Prasad and Hora suggest that for fish to be effective all vegetable matter and debris that may prevent access of fish to mosquito larvæ should be removed This means that areas of water to be treated should be kept clean and in as much sanitary condition as possible (a) all predatory fish should be removed (b) disconnected pieces of water separated by short distances such as borrow pits etc should be connected by a regular drainage system so as to enable the fish to wander every where (c) shallow pits and pools should be either filled up or deepened so that fish may be able to live in them even when the water is at its lowest level in the dry weather and (d) fishing should be strictly prohibited in such areas

For effective biological control of larvæ by fish it is essential to know the bionomics of the mosquito and ecology and biology of the fish The importance of fish in malaria control has been established for a long time but the habits of the various indigenous fish have not been scientifically studied in detail and have not been tried on a large scale in the field To prove conclusively the part that fish play as larvicidal agents and to determine the utility of various indigenous species Prasad and Hora (1936) suggested that as a preliminary measure two adjoining areas one heavily infested with malaria and the other comparatively free from it should be selected for survey An intensive survey of the fish fauna of the two localities should be undertaken due regard being paid to any correlation that may exist between the probable density of population of the mosquito larvæ in the different areas of the locality and the types of fish and density of their population in the same kinds of water Observations should also be made of the natural food of various types of fish by an examination of their stomachs

Covell enumerates the following requirements (based on Chaudhury s paper) for useful larvivorous fish

They must be small so that they can get about in the shallow water among weed etc

They must be hardy and flourish both in deep and shallow water

They must be able to breed freely in confined water areas

They must be able to stand transport and handling

They must be difficult to catch and able to escape their natural enemies including man

They must be absolutely worthless and insignificant as food

They must be top feeders and carnivorous

Gambusia satisfies the above conditions and is at present readily available from the Malaria Institute of India Delhi

CHEMICAL

Oil Paris green pyrethrum Oils Paris green pyrethrum and DDT are common larvicides Cuprous cyanide has also been used and found to be satisfactory as a larvicide under certain climatic conditions Paraformal dehyde soap cresol commercial cyllin creozote carbolic acid and borax have been used as larvicides but are not in use now Nesterwodskaja and Lubinski (1944) have re ported that phenothiazine (7 and 14 ounces per acre at 12 13 C) kills all mosquito larvae in 48 hours

Oiling L O Howard in 1892 first recommended oils as larvicide and suggested that the film of oil mechanically stops the breathing of mosquito larvæ The larvæ are killed not only by suffocation but also due to irritant and toxic action of oil mixtures Sir Malcolm Watson showed that mosquito breeding can be stopped even in running water by spraying the stream its banks and seepages with oil and pointed out that what is sold as crude oil or fuel oil varies greatly in composition in different parts of the world and that many of these oils do not make satisfactory anti malaria mixtures Some would not kill larvæ some would

dusted by hand 5 per cent when dusted with blowers 15 to 33 per cent by aircraft have been used) Metcalf and Hess report that *Anopheles quadrimaculatus* larvæ can ingest particles of 29 51 68 and 106 microns in 1st 2nd 3rd and 4th instars respectively De Andre reports that best results are obtained with Paris green 2 microns in diameter The only guiding factor for the necessary strength of Paris green to be used is a practical test in the field If a particular strength is not found effective it should be increased Numerous substances have been used as diluents The commonly used diluents in India are ash screened road dust sand slaked lime soap stone powder cement dust and saw dust For large areas like streams heavy diluents are often suggested The diluents should be passed through a screener before use The vehicle and the Paris green used are thoroughly mixed in the required proportion generally in a rectangular galvanised iron box supported on two pillars The mixture is dusted usually with hand bellows or rotary blowers Paris green has been sprayed with success from aeroplanes—one pound of Paris green per acre is usually required Paris green may also be applied in liquid form Since Barber used the Paris green solution in Greece Russell and Jacob (1939) and other workers have used it successfully in India A stock mixture of kerosene oil ½ gallon Paris green 2½ lbs castor oil 1 oz and white of 4-6 eggs shaken up in a pint of water can be used This mixture in dilution of 1 oz to 1 gallon of water can be used in a sprayer Paris green mixed with water (in dilution 1 in 500 or 1 in 250 suspension) has also been used (dose one gallon to 870 sq ft) effectively in shallow streams

Dusting and spraying with Paris green is a cheap anti larval method and is specially suitable for fields and irrigation channels Frequency of dusting depends on intensity of breeding and the climate If the development of the larvæ takes less than a week or so application every fifth day may be necessary in other cases application once a week gives quite good results It must be remembered that Paris green has no effect on eggs or pupæ of mosquitoes and does not kill culicine larvæ when applied in the usual

method The use of Paris green has almost now been replaced by DDT

Dichlor Diphenyl Trichlorethane (DDT) Its chemical synthesis was done as early as 1874 by a German chemist from Strassbourg In 1939 a firm in Switzerland (J R Geigy Company) during investigation for moth killing agents came across this chemical They promptly produced it under the name Gesarol In 1942 the New York Branch of Geigy Company received 200 lbs of DDT from Switzerland The Department of Agriculture in Washington immediately got it from New York Branch of Geigy Company and forwarded it to Orlando Laboratories It was soon found to have insecticidal properties against body lice In January 1943 chemists of the United States Department of Agriculture at Boltsville Maryland Laboratories identified it as Dichlor Diphenyl Trichlorethane Following its identification intensive research both in the field and the laboratories was taken up by British American Indian and other workers In a short time it struck a death blow to insects carrying diseases in various theatres of war It was soon found to be lethal to mosquitoes lice flies bugs and various other insects

DDT is a white crystalline powder nearly insoluble in water moderately soluble in petroleum and vegetable oils and readily soluble in most organic solvents It has 1 6 G per millilitre density Crude commercial forms vary in purity and may contain only 60 to 77 per cent pure DDT (*para para or p p DDT*) *p p DDT* melts at 108 -9 C It has a characteristic and pleasant odour and a tendency to clump Exposure to high temperature and humidity increases its tendency to clump It is toxic to most crustacea and insects Ellis *et al* (1944) report that gold fish weighing 6-10 G die after taking pellets of DDT 63 200 mgm per kgm body weight and frogs died after 40 to 72 hours on a single parenteral dose of 150 mg per kgm Rats and guineapigs after absorption of DDT through the skin showed toxic necrosis of the liver and kidneys The lethal dose for animals varies from 150 to 600 mgm per kgm In powder form it has no

adverse effect on the skin of human beings and is quite safe to use

Solubility in common solvents in per cent p p′ DDT at 27-30 C is as follows —

Toluene	38
Veg Turpentine	20
Malariol	[illegible]
Fuel Oil (Diesel) No 2	9
Fuel Oil (Diesel) No 1	7
Kerosene Crude	7
Kerosene refined	4

Solution of required strength can be easily made by breaking up the lumps of DDT and then making a paste with the solvent It can then be poured into the container The container should at least be ¼ full of solvent Finally the remaining solvent is poured in the containers The solution in the container is kept in the sun and stirred with a stick (or by bubbling air with a power driven air com pressor) The solution is ready for use in 3 days For immediate use DDT can be heated slowly on a hot plate and poured into the solvent when molten stirring all the time A 3 7 per cent solution can be conveniently made as follows A four gallon tin is filled with commercial DDT up to 3½″ from the top This approximates 22 5 lbs of DDT *Assuming that the powder contains 75 per cent of p′p DDT* when it is dissolved in 45 gallons of the solvent the resultant solution approximates 3 7 per cent solution of p′p DDT

Its effect on eggs and pupæ is negligible but is lethal to larvæ and adult mosquitoes

DDT as larvicide DDT is relatively non toxic to embryonic tissue It is interesting to note that there is selective absorption of DDT on the chitin in *vitro* Its *larvicidal action is due to ingestion of the chemical or* absorption or both

As a control measure 0 15 lbs (2 4 oz) of p p DDT per acre is found satisfactory *DDT malariol solution gives* better results than DDT kerosene mixture It is observed that 0 3 lb DDT per acre kills fish frogs snakes and other aquatic animal life Care therefore is *required* not to

exceed the strength of DDT in water used for breeding of fish The following have been used successfully

(a) 7 ounces of DDT to 1 gallon of 3rd quality kerosene oil resulting in a 5% solution One quart of this solution is sufficient for one acre

(b) 0 1 lb DDT per acre in thick vegetation up to 1 lb per acre for dusting

(c) $2\frac{1}{2}$ per cent to 3 7 per cent DDT solution in kerosene oil with approximate dosage of 0 15 lbs of DDT spraying with Kent type pneumatic knapsack sprayer per acre

(d) Five per cent DDT solution in kerosene oil in a bamboo stump with one end of bamboo plastered with mud thrown in the middle of the pond Dosage 0 2 lbs per acre

(e) One handful of 2 per cent DDT powder mixture Five pounds per acre

(f) Sand or step bricks soaked in DDT thrown in stagnant water

(g) 3 7 per cent DDT solution mixed with dry sand and made into balls thrown at intervals across water surface Balls made with mud are found ineffective

Even one to two quarts of 5 per cent DDT solution per acre have been found effective

The opinion is gaining ground that discrete application is preferable Five per cent solution in an oil of 46 dynes/cm spreading pressure gives good results on still waters Two ounces should kill all larvæ within 25 feet radius i e about 2000 sq feet DDT in emulsified solution have also given very good results

Whatever the method used one must ensure that the breeding surface is completely covered In every case care should be taken to distribute DDT uniformly especially along the water edge If spraying is done intermittently the intervals should not exceed 5 yards The density of vegetation and scum modify the effect for obvious reasons Pouring by hand or garden syringes dusting or throwing sand and bricks are not so effective and economical as spraying with knapsack sprayer or stirrup pump In South

East Asia Command during the war DDT was extensively sprayed from aircraft 0 3 to 0 6 lbs DDT per acre is usually effective 5 per cent solution of DDT were used singly or in formation flights with several aircrafts abreast The dosage of 2 to 3 quarts per acre of the solution controlled mosquito breeding in swamps Full destruction of mosquito breeding in streams covered with vegetation was not possible The DDT deposited on vegetation however killed the mosquitoes coming to lay eggs and those which were newly hatched Application of DDT by aircraft has since been developed to a high degree Several types of aircrafts including helicopters with various types of equipment are now employed *See also page 62 regarding DDT*

REFERENCES

Ellis M M Westfall B A and Ellis M D (1944) *Science* Nov 24, 477

Hora S L and Mukerjee *Table for identification of some Indian fresh water fish* Manager Publication Delhi

Nesterivadskaja K M Labinski G A (1944) *Tr Dis Bull* 41, 103

Prasad B and Hora S L (1936) *Rec Mal Surv Ind* 8 631-646

Raevsky G E (1944) *Tr Dis Bull* 41 543

Raina B L (1945) *Ind Med Ga* 80 273

Ramsay G C (1942) *Report of the Committee of Control The Ross Institute of Tropical Hygiene India Branch*

Idem (1944a) *Ibid*

Idem (1944b) *Personnel Communication* forwarding a note by J Robertson

Ribbands C R (1944) *J Roy Army Medical Corps* 82 157 64

Russell P F and Jacab V P (1939) *Jl Mal Inst Ind* 2 261 271

Sinha J D (1940) *Bengal Public Health Journal* II 23

Watson G (1941) *Bull Ent Res* 31 Part 4

Watson M (1942) *Some Emergency Anti malarial Measures Ross Institute Industrial Advisory Committee*

CHAPTER VII

ANTI MOSQUITO MEASURES

Various methods of killing the mosquito have been used viz trapping swatting fumigating with sulphur dioxide cresol lysol Izal chlorine gas etc and spraying with pyrethrum DDT BHC An effective practical and popular method at present is spraying with DDT or pyrethrum—DDT mixture

Pyrethrum Le Prince and James in 1926 Ross in 1936 and Meillon in 1936 Covell Mulligan and Afridi in 1938 reported remarkable results by spraying pyrethrum solution One part of 2 per cent pyrethrum extract in 19 parts of third grade kerosene oil was recommended A very effective spray can be prepared by soaking one pound of dried powdered pyrethrum flowers in one gallon of kerosene oil for 72 hours provided the flowers are of good quality (Covell 1941) Many proprietary products containing pyrethrum extracts are now available which are equally effective It is essential not only to spray the affected locality but also all buildings within about half a mile around it The spraying must be done thoroughly and systematically It is necessary to close all doors and windows open up all cupboards and almirahs etc (if any) and start spraying with the spray directed upwards Direct hits on mosquitoes need not be aimed at Pyrethrum [illegible] contact poison and its lethal action is most pronounced in atomised cloud The spraying in the room or hut should be continued till sufficient concentration of the solution is produced (causing very slight irritation to the eyes) The quantity recommended [illegible] 1 oz of spray per 1000 c ft of space The room should be left closed for about half an hour after the spraying The uninhabited huts or houses etc should not be neglected It is best to plan out a definite circuit for each set of houses Thorough spraying will be required in most places in the early morning not later than one hour after sunrise

The principle of adult spraying is that malaria can

only be transmitted by the female anopheline mosquito which, having *fed on a person with gametocytes in his blood* succeeds in surviving for at least 10 days and then has the opportunity of biting another susceptible human being The *object is not so much to prevent human beings from* being bitten by the mosquito as to reduce the longevity of the carrier species to such an extent that it cannot live long *enough* to become infective and as such cannot transmit malaria

A very simple hand sprayer (MISH pattern) has been designed by the Malaria Institute of India Excellent results are obtained with petrol driven paint sprayers Electric sprayers of the same pattern are equally useful The American aerosol bomb is a great improvement over the hand sprayers All that is required is to unscrew the cap over the nozzle of the bomb Immediately after the removal of the cap a fine mist containing the insecticide fills the room Sesame oil acts as an activator of pyrethrum enhancing its insecticidal properties and Freon 12 (dichloro di fluormethane) acts as the propellant providing the necessary pressure to expel the insecticide About 4 seconds are *required to spray* a space of 1000 cubic feet Each bomb can effectively kill all flies and mosquitoes in 100 000 cubic feet DDT with an auxiliary solvent is now *added to pyrethrum—Freon 12* solution

DDT The DDT is absorbed through the tarsi of adult mosquitoes and in a few hours the insect becomes inactive *It gets tremors due to the neurotoxic* poison and dies If the dose of DDT is small and contact time short the death may take 12 to 24 hours During the contact and the time of *death it often shows increased activity* and *is not* usually found near the place where it had the fatal contact The dry powder has no repellent action on the mosquito A 5 per cent solution of *DDT in 3rd grade kerosene oil* is *often* used For killing adult mosquitoes optimum results may be obtained with 85 mgm p p DDT per sq ft i e one quart of 3 7 per cent pp *DDT* solution per 500 sq ft With residual deposits of 100 to 200 mgm p p DDT per sq ft the residual fatal contact effect can be prolonged The residual effect is shortened on surfaces exposed *to sunlight*

and rain porous and painted surfaces The residual effect has been reported to last several weeks and months

Barrier spraying It was observed during trial in the Fourteenth Army (Afridi) that spraying of a site and a belt of 50 yards round it including buildings on the inside and the outside and every feature in the terrain with 5 per cent DDT in kerosene oil at the rate of 5 gallons per acre prevented 90 per cent of prevailing mosquitoes from infiltrating into the protected zone Spraying of a 50 feet belt only round a camp site was not so effective as in the case where camp site itself was sprayed Area and zone spraying requires repeated spraying after 10 days and therefore this method can be used only if the stay in a place is of short duration

Residual spraying should be started in and around the buildings one month before transmission of malaria is due to commence and repeated monthly throughout the malaria season If it is found that the infective mosquito rests on the exterior of the building after taking its blood feed the exterior of the building should also be sprayed The spraying should be done so as to deposit effectively DDT crystals in the required strength on all the surfaces where the mosquitoes are likely to rest It is done effectively with the Four Oaks pattern knapsack sprayer or stirrup pump with special nozzle The minimum dosage of solution which can be applied evenly from distance of one foot from the wall in the case of Four Oaks sprayer is one quart per 250 sq ft The stirrup pump with the same quantity can spray up to 500 sq feet By increasing the distance of the nozzle from the wall the dosage of solution can be decreased Although the stirrup pump requires two persons to operate and its rubber tubings sometimes burst during spraying it can effectively spray with a speed of 4 feet per second without contaminating the clothes of the operator to a considerable degree A few precautions are essential during spraying No food cooking utensils etc should be allowed to be contaminated with DDT The persons employed to spray should use protective eye shields gloves and overalls while spraying and should have a bath with soap and hot water after spraying

Other Insecticides A lot of experimental work has

been done lately to alter DDT molecule and also to change the number of chlorine atoms in DDT molecules to substitute other chemical groups such as Flouro, Bromo and Methoxy A number of solvents and emulsifiers have been used

DDD DFDT, DMDT and the like are less toxic to human beings and insects DDD has almost the same or better action than DDT on larvæ but is less toxic to adult mosquitoes By completely altering the structure powerful insecticides like benzene hexachloride chlordane or octa chlor, toxaphene or *chlorinated camphene and parathion* have been produced

Imperial Chemical Industries Ltd has introduced Gammexane which contains the gamma isomer of benzene hexachloride 6 5 per cent of this isomer is present in Gammexane powder P520 Ross Institute of Tropical Hygiene recommend a single dose of 10 mg gamma benzene hexachloride per square foot to obtain control of adult anopheles for a period of at least three months Twelve ounces of Gammexane P520 mixed with one gallon of water and dispersed at the rate of half a gallon per 1000 sq ft give a deposit of about 11 mg gamma B H C (gamma isomer) per square foot

Chlordane has been widely used with success in Italy against house flies Toxaphene has the same residual toxicity as benzene hexachloride and chlordane High toxic effect is also claimed for 497 and 118 but sufficient data are not yet available to give any definite opinion Hexa ethyl tetraphosphate tetraethyl pyrophosphate and diethyl nitro phenyl thiophosphate (parathion) are other insecticides belonging to phosphate series It however has not prolonged residual effect but is effective against immature stages of insects In the phosphate series parathion is the most important

Synergists

Work is also being carried out on synergists for DDT Synergists can be put in two categories viz those affecting physical properties of the residual deposit and those which are toxic in themselves Gum rosin 10% is often used Gum rosin acts as nuclei *for DDT crystals* They not only tend

to increase the toxicity of the DDT but the adhesive property of gum rosin prolongs their residual action The common examples of toxic complementary synergist are of pyrethrum and DDT methoxychlor and DDT and chlordane and DDT

It may be emphasised that the use of modern insecticides like DDT as a residual spray has proved that it is the most effective and practical method of controlling malaria especially in rural areas It is obviously necessary to organise and plan the spraying after carefully considering the ecology of the local mosquitoes especially the local vector and investigating local conditions

Love call trap Reference may be made to an interesting experiment carried out by Kahn *et al* (1945) They have found that mosquitoes make various sounds while flying and by beating wings or rubbing tarsi against wings These sounds include a love call On hearing the love call (audible and inaudible to human ear) of a single female mosquito numerous male mosquitoes turn their antennæ and hypopygium towards the female and burst into a chorus Work is being continued to produce the love call mechanically in DDT treated spots in the hope that all male mosquitoes within hearing distance will come into the trap and die This would avoid spraying of large areas with DDT.

Personal protection Personal protection from mosquito bites by suitable house construction use of nets suitable clothing and repellents are still some of the effective methods of preventing malaria infection

House construction Screening of buildings in malarious localities is of great value The following figures by Hanafin as early as 1928 showing the result of screening in British troop barracks in Lahore speak for themselves —

Year	Admission per 1000 screened barracks	Unscreened
1926	182 12	672 35
1927	45 61	265 98

The main objection to screening often put forward is that the atmosphere inside screened hou es is suffocating

and the rooms become dark Lack of light and ventilation is often noticeable in houses which were originally built on the usual popular plans, and of which the screening of doors and windows was done afterwards Covell (1941) recommends that the following principles should be observed

Building to be screened must be built and kept in good repair *Door frames should be made of seasoned wood* with iron brackets at the corner and should not sag on their hinge A double wire attached diagonally across the lower half of the door and tightened up with turn buckle will tend to prevent this No attempt at edge fitting should be made The door should be made to fit against a ¾ batten all round the inside and sufficient space allowed for the door to swell in wet weather without scraping at the bottom A light strip of wood should be nailed across the door frame at about the height of a man s shoulders This is to push against when opening the door There should be two fastenings for each door one half way up the top section and one near the bottom The lower panel of the door may be strengthened by wire netting as a protection against kicks and against dogs attempting to enter or go out Doors should open outwards so that mosquitoes resting on them may be driven out when they are opened They should be placed on the windward side of the house for the mosquitoes tend to congregate on the leeward side It is of great advantage to have double doors with a porch or vestibule at least 6 feet in length between them Strong springs should be fitted to the doors to ensure that they will remain tightly closed when not in use *Every aperture in the building should be screened* No removable screens or shutters should be used No screening should be used within one foot of the floor because it is liable to be damaged when the floor is scrubbed No furniture should be placed against screening Putting wire *gauze on existing doors and windows* affects the ventilation considerably Windows should be provided for the ventilation lost In Federated Malay States when mosquito proof houses are built and 16 mesh wire gauze used the window area is doubled to make up for the loss in ventilation caused by the gauze The gauze used in the barracks of

British troops in India was 14 mesh and 28-30 SWG giving an aperture of 0 055 to 0 057 * The ventilation and lighting can be improved by electric lights and fans and by designing the house especially for screening (screens are mainly put round the verandahs) For screening to be effective the persons living in it should not remain out of the house after sunset and before sunrise

The estimated cost of a mosquito-proofing building in normal times is about 2 to 3 per cent of the total cost of building. Temporary labour camps can be made mosquito-proof by the use of condemned mosquito nets on doors and windows

Nets The mosquito netting with a mesh of 28 to 29 holes in a square inch and made of 30/40 cotton will keep mosquitoes out Nets should be preferably white rectangular in shape with netting also in the roof and no openings inside They should be set down before sunset The free border should be tucked in continuously all round the bedding No portion of it should be allowed to flap about loosely When going to bed only the minimum portion of the net should be lifted to enter and then it should be carefully tucked in again under the bedding Nets should be turned inside out preferably daily and the pole corners searched for mosquitoes

Protective clothing People should wear long sleeve shirts slacks or *pyjamas* or *shalwars* The *dhoti* does not give the necessary protection Mosquito boots or Wellington boots are very useful In any case every attempt should be made to so clothe oneself that the minimum amount of body is laid bare for mosquitoes to bite Veils and gloves have been used in various armies for guards on duty

Repellent Plain citronella oil applied 3 hourly gives satisfactory results while naphthalene conc ext of pyrethrum cream gives almost the same results A non greasy vanishing cream can be made of gum tragacanth powder [illegible] parts oil citronella 2 parts pyrethrum 2 per cent 80 parts water is added after mixing all the ingredients The cream should be liberally applied at 2 hourly intervals on

* Where *A minimus* is the vector as in Assam 16 mesh 28 SWG giving aperture of 0 048 inch is required

all exposed parts of the body Dimethyl phthalate and dibutyl phthalate in liquid form are agreeable to use and are very effective especially the former, even when a few drops are rubbed on exposed parts and have replaced the creams used formerly Its effect lasts for about 4 hours

D M P fish nets Afridi *et al* (1945) report that ⅜ inch mesh nets (fish nets) and garments impregnated with 0 42 c c dimethyl pthalate give complete protection from mosquito bites for 72 hours Nets treated again conferred protection for longer periods

REFERENCES

AFRIDI M K AND ARTHUR J H (1945) *South Africa Med J* 19, 361 365

COVELL G (1941) *Malaria Control by Anti mosquito measures* Thacker Spink and Co (1933) Ltd Calcutta

COVELL G (1942) *Anti mosquito Measures* Health Bulletin No 11 Manager Publication Delhi

KAHN M C CELESTIN W AND OFFENHAUSER W (1945) *Science* March 30 335-6

MALARIA SURVEY & ANTI MALARIA CAMPAIGN

It will be obvious from the foregoing account that before starting an antimalaria campaign in an area it is essential to carry out a preliminary survey The survey should include the study of physiographical features meteorological records mortality and morbidity by age groups directly or indirectly due to malaria total death and birth rates by age groups in different parts of the year spleen rate* and parasite rate amongst the children of the locality (children between two and ten years are most suitable for the purpose) seasonal prevalence of malaria species of anopheline their breeding places flora and fauna of the breeding places bionomics of the mosquitoes and investigations regarding the carrier species Dissection of gland and gut of mosquitoes with a view to determine the infection rate and further investigations in detail regarding the bionomics of the local mosquitoes especially the vector species will have to be continued as a preliminary survey Study of social and economic condition of the people and industrial and agricultural problems should not be overlooked

After deciding the measures to be adopted in a locality it will be necessary to plan a scheme incorporating permanent and temporary measures and undertake further investigations of the antimalaria problems of the locality In practice it is useful to divide large areas into small self contained units It is the small units which carry out the most important work in the field and are responsible for control measures in a locality Under a unit scheme the area of malaria control should include areas ½ to 1 mile beyond the periphery of a locality to be protected The

* Infection with malaria gives rise to enlargement of spleen The areas are classified usually as follows Over 50% spleen rate hyperendemicity, 25 50% high endemicity 10-25 low or moderate endemicity 10% healthy After 10 years of age immunity starts and by about years of age spleen may become normal Spleen rate therefore is of children between 2 10 years

whole area is divided into sub areas under a malaria inspector Each sub area may be further divided into six zones The work is so arranged that a field squad works in one zone at a time in rotation so that each such zone is thoroughly treated at least once a week It is necessary to keep records of the work done The following diaries are suggested *

(1) METEOROLOGICAL RECORD

Year *Month*

Date	Maximum Temperature	Minimum Temperature	Relative humidity Morning Evening	Rainfall	Prevailing wind

(*Records must be made at specified fixed times daily* Records of sub soil water may also be kept if possible)

(2) MOSQUITO CATCHES

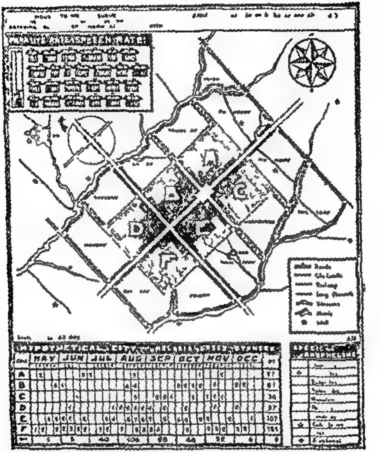
Date *Month* *Year*

Species	*Number*	*Cattle sheds*	*Houses*	*Number from each Mosquito catching station 1 2 3 4*	*Precipitin test*	*Dissection Gland Gut*

Various traps have been recommended for catching mosquitoes A type of trap used with success is a simple wire ring $2\frac{1}{2}$ feet in diameter over which a black or red cloth skirt is stitched with purse string at both ends These are hung two feet from the ground Dark red colour appears to attract mosquitoes In an experiment carried out with red and black traps 1147 mosquitoes took shelter in red traps and 772 mosquitoes in black traps (Raina

* With regard to details of malaria survey reference should be made to Health Bulletin No 14 Malaria Bureau No 6 *How to do Malaria Survey*

ONE OF THE MALARIA SURVEY AND CONTROL CHARTS



The chart shows parasite and spleen rates in the surrounding villages and area under control the species of anopheline larvæ marked where th y are found breeding area under control divided in six zones A B C D E F and the days on which they are visited by malaria-control squad and a table showing the number of malaria cases weekly from each zone

1943) , A red earthenware *chatti* is almost as good Traps when used are put in corners of rooms in the catching sta tions In actual practice a well trained insect collector can

catch more mosquitoes than the traps and most of the field workers have practically given up using traps Such catches can be of value only if the time duration and technique of catching mosquitoes are uniform Usually a large number of catches in a day indicate breeding places nearby for which search can be made For special investigation further information can be added in the same diary viz catches during the first second third and fourth quarters of night etc

3 LARVAE

Year			*Month*		*Date*
Place	Type of breeding place	Quality of water	Flora vegetation	Fauna	Species

(Labelled specimens should be brought to the Antimalaria Officer for inspection and verification)

4 INCIDENCE OF MALARIA BY AREAS (Zones if possible)

Year					*Month*					*Date*
Serial No	No of houses	Name S/o	Sex	Age	B T		M T		Mixed	
					Tropho	Gm	Tropho	Gm	Tropho	Gm

B T = Benign tertian M T = Malignant sub-tertian
Q = Quartan Tropho = Trophozoites
Gm = Gametocytes

Spleen rate
Parasite rate

5 EXPENDITURE

6 MEASURES EMPLOYED

The above figures can be consolidated weekly and numbers shown from each zone or barrack lane or street

The data so collected can be put down on enlarged maps with different signs especially showing breeding places (permanent and temporary) mosquito catches etc Maps are of great value and show all the facts at a glance The secret of success lies in good planning sound supervision and ability of the organiser to get the work done in the way it should be done

Choice of Control Measures

Measures required for different places will vary Permanent measures (including biological) should be adopted wherever possible The former requires a large investment but saves recurrent expenditure except the cost of maintenance Certain general temporary measures will be always applicable It has been argued that antilarval measures are conducted in the field and consequently are easily supervised whereas success of antimosquito measure especially spraying is easier to organise easily popularised and gives results in a very short time Both antilarval and antimosquito measures play an important part in most antimalaria schemes The fact that a judicious combination of antimosquito and antilarval measures gives best results is indisputable Antimosquito measures alone have lately given promising results The time to start antilarval measures is one month before the malaria season sets in and the antimosquito measures a fortnight before the onset of the malaria season If funds do not permit to carry out this procedure antilarval measures should be started to begin with and a careful watch kept on the mosquito catches and incidence of malaria Any rise in a zone in the figures of either or both is a warning that spraying should be started without delay During the height of the malaria season or when malaria incidence is expected to rise *spraying to kill adult mosquitoes should be augmented* During the non malarious season measures to kill adult mosquitoes may be suspended In any antilarval scheme greatest attention must be paid to control species responsible for carrying malaria in a locality but other mosquito breeding places including culicine should not be neglected

Permanent measures including biological should be completed before the malaria season sets in

REFERENCES

CHRISTOPHER S R SINTON J A and COVELL G (1941) *How to do Malaria Survey* Health Bulletin No 14 Malaria Bureau No 6 revised by COVELL G Manager of Publications Delhi

RAINA B L (1943) *Photo Bionomics of Mosquitoes of Kangra Valley* (not published)

Chapter IX

CHEMOTHERAPEUTIC AGENTS

Intensive research (pharmacological chemical and clinical) to find a drug or drugs to ensure a radical cure of malaria has been in progress for many years Cinchona and quinine held the field for a long time Since Paul Ehrlich in 1891 reported that methylene blue stains the malaria parasite and is likely to damage it investigations on synthetic drugs were started leading to the discovery of Plasmoquine by Schuleman and his colleagues in 1924 Mutsche and Mauss carried on the work started by Schuleman and discovered synthetic schizonticide Atebrin in 1930 and Bayers introduced it in the market in 1931 Similar drugs soon appeared in different countries Acriquinine in USSR Quinacrine in France Acridin 10 in India Mepacrine in England Since then a number of promising chemotherapeutic agents have been introduced Many of them are still in an experimental stage Experiments are being carried out on more scientific basis than before Not only the action of the drugs on different species of parasites in their different phases (sporozoites pre and asexual erythrocytic forms and gametocytes) are investigated but parasiticidal action on different strains of the same species is also observed

Quinine 6 methoxy α (5 vinyl 2-quinuclidyl) 4 quinoline methanol

Quinine is an effective schizonticide It is effective against asexual forms of all the parasites It has hardly any effect on the gametocytes of *P falciparum* but destroys effectively gametocytes of *P vivax* and slowly those of *P malariae* Quinine taken by mouth is little absorbed in the stomach and passes through unchanged Hydrochloric acid of the gastric juice converts insoluble salts into soluble hydrochloride It is precipitated in the duodenum and absorbed as such Bile aids in its absorption Alkalies given before quinine are reported to increase the diffusion

through the mucous membrane The quinine circulating *in the blood (concentration usually* 1 250,000) is taken up by internal organs and split up and destroyed The remainder is excreted by the kidneys excretion begins about ½ hour after taking the quinine and can be detected in urine by Mayer s reagent Salts requiring preliminary hydrolysis are absorbed slowly Opinions differ regarding the action of cinchona alkaloids Morgenroth observed that quinine forms a film on the surface of the red cells and *prevents merozoites from entering the cells Hegner states* that the site of action is intra corpuscular Bass assumes that quinine renders the cells permeable to blood plasma, so that parasites are destroyed by lysis Yorke and Macfie suggest that quinine kills some parasites by direct action while others are killed by the defence cells of the body activated by parasitised products (Field as quoted by Jogleker 1940) Taliaferro (1949) states that Quinine acts directly on the parasites and may kill them though their death is more commonly the effect of immunity process Moulder (1950) suggests that quinine appears to exert its effects through preventing (the formation of the postulated reactive 2-carbon particle) pyruvate oxidation in the early stages Seabra (1950) with an ultramicroscope *observed that when blood and colloidal quinine solu*tion placed together the quinine colloidal particles absorbed on the RBC the degree of absorption depended on the reaction of the blood *If* acid absorption was *intense if* alkaline it was feeble or absent

The usual dose of quinine sulphate is gr vii to gr x thrice daily by mouth giving a plasma concentration of 4 to 5 mgm per litre In children the dose is usually calculated at 1 to 1½ gr plus half the age In severe cases with hyperpyrexia hyperparasitaemia or vomiting gr x of quinine hydrochloride or bihydrochloride in 20 c c of 25% glucose solution intravenously given at the rate of 2 c c per *minute or quinine hydrochloride gr x* (preferably mixed with urethane) in 2 to 4 c c of distilled water *intramuscularly is* usually given

The Malaria Commission of the League of Nations recommended that the standard product of cinchona should

contain not less than 70 per cent of crystallizable alkaloid of which at least 1/5 should be quinine This was included in the British Pharmacopoeia 1932 as totaquina which is as effective as quinine Acton (1920) Acton Cwajel and Dewy (1921) Prain (1924) Acton and Knowles (1924) Fletcher (1925) Berkely Hill (1926) and James (1927) reported on great value of cinchona febrifuge Hicks and Dewan Chand (1935) held the view that therapeutically quinine and totaquine are of equal value Napier in 1945 made the interesting observation that the recent work has in no way questioned the efficiency of quinine and other cinchona alkaloids On the contrary it has confirmed all previous works regarding the antimalarial activity of these alkaloids and more specially of the mixed alkaloid preparations which some of the poorer malarious countries may on economic grounds still prove to be the drug of choice for the mass of population It may also be added that MacGilchrist (1915) working in Calcutta showed that parasite clearance in BT obtained with quinine in 4 7 days 5 5 with cinchonine 5 with quinidine and 5 6 with cinchonidine In MT infection the figures were 6 1 5 6 4 85 and 4 3 respectively showing that in BT quinine acts most rapidly while quinidine in MT Lane quoting Cordes (1924) and Ciuca *et al* (1925) observed that in MT cinchonine is less satisfactory than quinine and chinconidine was less effective than quinine or cinchona febrifuge respectively . Workers of Medical Research Council of the United Kingdom reported in 1926 that quinine and quinidine are equally effective Pranger and Filer (1949) have recently reported that cinchona alkaloids act synergistically with each other in blood induced infection in bird malaria They also observed that combination of cinchonidine and quinine produce more favourable results than quinine alone in blood induced infection of *P relictum* and *P gallinaceum*

The route of administration of quinine has been a subject of great controversy particularly the intramuscular injection Alkaloid injected intramuscularly causes tissue necrosis which may involve nerves and blood vessels in some cases abscess formation occurs and infection with tetanus is possible (if proper aseptic precautions are not

taken) Clayton (Lane as quoted by Joglekar *loc cit*) remarks that giving an intramuscular injection is to push into a patient with a hypodermic syringe a lasting conviction that if it has come to a choice between bitter taste and bitterly painful experience it is better to take quinine by the mouth after all In case of intravenous injection action is rapid (90% passes from circulation within a minute of injection) and without pain Toxic symptoms are rare if the injection is given slowly

Although many of the synthetic antimalarials have been found effective against acute attacks opinions regarding the prompt use of intravenous quinine in emergency cases like those of cerebral malaria are unanimous (Covell 1949 Black 1949)

ATEBRIN (MEPACRINE QUINACRINE) 6 chloro 9 (4 diethyl amino I methylbutylamino) 2 methoxy acridine

Its action is more or less like quinine It is a polyvalent schizonticide Its effect is more prolonged than that of quinine It does not destroy the gametocytes of *P falciparum* It is extensively localised in the tissues and slowly released Large loading dose is therefore necessary to build plasma concentration Headache restlessness and gastro intestinal disturbances may be noticed Yellow staining of the skin may be seen but is transient The *initial loading dose for effective clinical cure varies from* 0 6 g to 1 0 g The dosage commonly used is given below

	1st day	2nd day	Succeeding *five days*
For partially immune	0 6 g	0 3 g	0 3 g
For non immune	1 0 g *or* 0 9 g or 0 6 g	0 3 g or 0 6 g	0 3 g

PLASMOQUINE (PAMAQUIN) AND OTHER 8-AMINOQUINOLINES

The action of the plasmoquine group of drugs on schizonts of *P vivax* and *P malariae* is considered inferior to quinine and has hardly any effect on schizonts of

P falciparum On the other hand it is a polyvalent gametocide especially a powerful gametocide for *P falciparum* It was known as early as 1928 that relapse rate of *P vivax* under quinine plasmoquine treatment can be reduced Herein lies its special advantage It is relatively a toxic drug Cynosis due to the formation of methaemoglobin haemoglobinuria abdominal pain and vomiting have been often observed and its routine use is not recommended Pentaquine and Isopentaquine in the order stated are less toxic than pamaquin The dosage usually recommended is 0 06 g pentaquine base daily with 2 0 g quinine sulphate for fourteen days Pentaquine monophosphate contains 75% of the base The patient should be under hospital observation when taking these drugs for obvious reasons

CHLOROQUINE DISPHOSPHATE AND RELATED 4 AMINO QUINOLINES

Chloroquine relieves acute attacks of malaria and is a powerful suppressive drug against falciparum infection Partially immune have been reported to be cured by a single dose of [illegible] 5 g Like mepacrine plasma concentration is built up slowly unless initial loading dose is given

It is very active against all asexual erythrocytic forms Generally clinical cure is obtained in two to four days as against a week with mepacrine treatment None of the other 4 aminoquinolines (santochine oxychloroquine etc) appear to be superior to chloroquine The dosage used in the U S A and Venezuela is as follows

	1st day	Succeeding days
U S A	1 0 g divided in two doses	0 5 g for three days
Venezuela	1 5 g divided in three doses	1 5 g divided in three doses on second day only

Camoquin also has been favourably reported

PROGUANIL (PALUDRINE) N_1 p-chlorophenyl N isopropyl diguanide

It is a powerful schizonticide in benign tertian and malignant tertian malaria Malignant tertian infection can thus be completely cured It is believed to be the only antimalarial which *in non toxic dosage* is a *true casual* prophylactic against malignant tertian infection There is *wide margin of safety between toxic* and therapeutic dose Paludrine monohydrochloride contains 86 5% of paludrine base The usual dose for adults of Paludrine is 0 3 g once or twice daily for five to ten days Slight toxic effects like vomiting and renal irritation have been observed But the toxic symptom disappears on the reduction of dosage or if the drug is stopped for a day or two It has been *recently reported from Africa* that attacks of fever resulting from Rhodesian strain of *P falciparum* were not controlled for three or four days after paludrine therapy and attacks of malignant malaria were reported amongst persons who were under paludrine suppressive treatment Consensus of opinion however is that paludrine is still the drug of choice and in case of strains like the African mentioned above paludrine mono hydrochloride should be reinforced with mepacrine or chloroquine It may be added that the action of paludrine is less rapid than quinine mepacrine and chloroquine *especially in P vivax infection In emergencies therefore* its use alone is unsuitable M 5943 (N 1 4 dichloro phenyl N^5 isopropyl diguanide) *is reported to be more* active than paludrine and clinical trails are in progress

Sulphonamides have been referred to as effective in *P knowlesi* in Rhesus monkey (Coggshell 1938) and S diazine S merazine and S thiazole as suppressive in *P gallinaceum* infection in fowls S diazine S merazine and S methazine are stated to be most promising in human malaria especially in *P falciparum* (Covell 1943)

Investigations done at the Malaria Institute of India *showed that the following drugs have no effect on malaria*

Alstonia scholaris A Gad Antique Quine Chirvasal Coffee Husk *Degan s remedy Fraxine* malacophylla Hindscout HT7 Jwaraghna Saptaparna Karanjiwa

seeds Lichtenstein cure malaridol Sunine Tinospora cordifolia Vitex peduncularis

It will be seen from the above that quinine mepacrine chloroquine and allied 4 aminoquinolines and proguanil are effective in the treatment of the clinical attacks of malaria Chloroquine and proguanil are at present the drugs of choice In relapsing vivax malaria concurrent treatment with quinine and 8-aminoquinoline such as isopentaquine may be preferable

SUPPRESSIVE TREATMENT

It is generally agreed that the following drugs will effectively suppress malaria

Mepacrine hydrochloride	*Non immune* 0 1 g daily (preferably with build up of 0 3 g daily for 5 days) *Partially immune* 0 2 g twice weekly or 0 3 g weekly may be useful for mass prophylaxis where the intensity of malaria is not very high 0 1 g daily is most satisfactory	The daily dose to be continued in case of falciparum for at least three weeks after exposure
Chloroquine	0 25 to 0 5 g base once weekly on the same day of the week	
Proguanil	0 3 g once a week in hyperendemic areas In other areas 0 1 g to 0 3 g weekly have given promising results	

POSTSCRIPT

The happiness and prosperity of the people are closely connected with the degree of the health which they enjoy Varied aspects of public health problems are intimately related to the social and economic conditions of the people the availability of trained personnel material and equipment, the extent of the country s capacity, a co-ordinative machinery and adequate control to ensure carrying out of plans experiments and research

India despite its rich natural resources is a very poor country poor in goods poor in education poor in health The per capita income in 1939-40 was Rs 67/ per year During 1946 47 it was Rs 228/- On such a low income people have to eat, clothe themselves and live In pre war days the cost of the cheapest balanced diet alone was Rs 48/- to Rs 72/- per head per year The cost of living has considerably increased since * Education is poor about 88 per cent of the people being illiterate Health education is poorer still Doctors and nurses are limited Only about one doctor to 6000 and one nurse to 43 000 are available Facilities for specialist training and research are patchy Coupled with such an unfortunate economic and educational background the standard of public health is one of the lowest in the world Famines and epidemics are not infrequent The following figures for 1937 quoted by Grant (1944) tell a tragic story

	Expectation of life	Death rate per 100	Infant mortality per 1000 births
Australia	67 years	9 4	37
England & Wales	63	12 4	58
Japan	47	17 0	106
Undivided India	27	22 4	162

* The Index number of wholesale prices in March 1950 was approximately as follows

In India amongst the preventable diseases malaria claims first place in importance It is doubly unfortunate that to a great extent malaria is the creation of man

The responsibility for public health administration lies mostly on Provincial now State Governments But the control of the State Governments over local bodies is so weak that not much progress has been made The report of the Simon Commission (1930) is worth repetition

The result of the legislative and administrative action taken in accordance with the scheme of the reforms was in effect to deprive the new Ministers of local self governments of powers which were essential if they were to perform their task successfully

As to the urban population the report of the second meeting of the Central Advisory Board of Health 1939 recorded that According to available information nearly half the districts and three quarters of the municipalities in British India are still without qualified health officers In many of the areas visited by us we have been unfavourably impressed with the standard of health administration and with the manner in which these duties have been performed Health Officers are to be found in most of the larger municipalities but their work is too often ineffective because they have incomplete control of the health organisation or because their recommendations fail to receive active consideration from their councils A few municipalities and corporations like Bombay are notable exceptions It is obvious that scientific preventive and curative services are still beyond the reach of 80 per cent of the men women and children of India Progress has been made in the last few years but it has been patchy and limited to isolated areas Taking India as a whole the menace of malaria is no less than it was before as is evident from all India mortality and morbidity figures With the brief account set out in previous sections in mind one is forced to the conclusion that the malaria problem cannot

(Base year ending August 1939 = 100)

General index	392 4
Food articles	396 2
Cereals	434 0
Pulses	440 0

be adequately solved without the solution of economic educational and other vital problems referred to above The message of health can be brought home to the people not by preaching alone but also by providing facilities to put into practice what they are taught It is futile to ask a poor farmer to use mosquito nets or canvas mosquito boots so long as he cannot afford more than a loin-cloth and at least a pair of old sandals (*chappals*)—the latter usually to be kept tied at the end of the stick resting on his shoulder to prevent wear and tear and used only when absolutely necessary while walking on hot sand or thorny ground A malariologist obviously cannot plough his solitary furrow He has to take the help of the economist the educationist the agriculturist the engineer the lawyer and the State Consideration of vast and varied problems is essential for the study of the health problem of a country in its true perspective It must be emphasised that large tracts of land can be brought under cultivation if malaria problem is solved

The solution of the malaria problem in India requires the serious consideration of five principal factors viz (1) education (2) organisation (3) medical protection (4) legislation and (5) funds

(1) EDUCATION

(a) Health education must form a part of general education and should be appropriate for the age of the child

(b) The sanitary conscience of the public should be awakened by intensive and extensive propaganda Propaganda by means of leaflets pamphlets, posters exhibition films etc has its own utility but unaided by practical demonstration it hardly serves its purpose as most of the people do not comprehend what exactly the leaflet contains or the poster denotes For propaganda to become successful practical demonstrations are essential Medical men can form an All India Antimalaria Association Such an Association can play a very effective role

(c) Malaria should be introduced as a special subject in all the medical schools and colleges of India A chair for teaching malariology should be introduced in the universities Even if only one question on malaria is asked in an examination paper of Hygiene and Public Health it will stimulate the interest of medical students in malariology Facilities for field work and research work should be available for the post graduates in all universities Refresher courses for already qualified medical personnel will prove of great value A large number of medical men engineers malaria assistants and inspectors will be required Every registered medical practitioner can be kept informed on current ideas concerning malaria control through circulars by a Central Health Organization

(2) ORGANIZATION

Malaria control should be centralised and not left entirely to the local bodies A scheme more or less on the following lines can ensure efficiency and uniformity

(a) *Central Board of Malaria Control* The members of the Board can be selected by the Central Advisory Board of Health and should include amongst others a Consultant in malariology There should be a Director of Malaria Control in India who can work as Secretary to the Central Board and through him the Board can exercise executive control over the States The Board can draw out a 15 year plan in collaboration with the World Health Organisation for dealing with the menace of malaria and should ensure that it is carried out

(b) State Governments should have a Deputy Director of Malaria who will be directly responsible through the Director of Public Health to the Director of Malaria Control India The State Governments should have a State Malaria Control Board which should include the Minister of Public Health the Director of Public

Health the Chief Engineer, Directors of Agriculture Fisheries Botanical Gardens the Finance Minister and Conservator of Forests Representatives of Zamindars Industries Railways and Municipalities can be co-opted The Deputy Director Malaria Control, can act as Secretary

(c) *Districts or a group of districts* should have an Assistant Director Malaria Control with a *mobile field laboratory consisting among others an entomologist* When the preliminary surveys are completed the field laboratories may be kept only in one or two districts in the State (except those which are non malarious) Every district should have an antimalaria committee more or less on the same lines as State Committees A detailed health survey including *an entomological survey of the whole of the inhabited parts of India is essential* This should be started in hyperendemic malarious areas first All constructions of roads canals factories and residential buildings ought to be approved by a *malariologist*

(d) In every sub-division endemic or hyperendemic districts or in Tehsils there should be an antimalaria officer and an antimalaria committee Staff for malaria control will obviously not be necessary in malaria free areas It may be stated that some States have already started Malaria Control Organisations

(3) MEDICAL PROTECTION

For the treatment of 100 to 200 million sufferers from malaria qualified medical men hospital accommodation nursing facilities and necessary quantities of quinine and synthetic drugs are required It was estimated that there were only 47,500 doctors and 7 000 nurses in United India and if one doctor for 2 000 of population is necessary India will require 185 000 doctors Adequate planning for the production of drugs like quinine and proguanil is essential

It is estimated that the quantity of quinine required for India is about 1 5 million pounds The quantity consumed in pre war years was about 210 000 pounds out of which only about 70 000 pounds was manufactured in India Parts of Assam Bengal Orissa Bhutan Sikkim Madras Travancore Cochin Mysore and Coorg are suitable for cinchona cultivation It is reported that 38 000 acres of land (each acre capable of producing 100 to 200 pounds of quinine per year) are available in India It will be observed from the above figures that India can not only become self supporting for its quinine but can produce ten times its requirements (Krishnan 1940) The recently discovered chemotherapeutic agents have now to a great extent replaced quinine Their manufacture in the country will require change in cinchona cultivation policy There is no reason why chemical and pharmaceutical works should not be able to produce drugs for India s need In view of their therapeutic value we must now work out carefully our requirement for malaria control stores equipment and drugs and plan their production in the country Production of quinine may be necessary for the time being till the country starts producing the new chemotherapeutic agents in sufficient quantity to meet the total requirement Their distribution will require considerable planning and can be done by the Central Malaria Control Board Apart from curative drugs large quantities of DDT suitable mixtures of oils paris green and pyrethrum etc will be required for malaria control Pyrethrum requires a high altitude with a dry climate and well drained soil and it is very encouraging to find that it can be successfully cultivated in Kulu Palampur Kashmir and Nilgiris It is estimated that 15 000 short tons (2000 lbs for a ton) will be required for India s need per year This will require 120 000 acres of land to produce Once DDT and other new insecticides in sufficient quantity become available in the country the cultivation of pyrethrum can be reduced or completely replaced by other crops Economic aspect of malaria control measures is vital With the assistance of the World Health Organisation supplies can be arranged for the time being from abroad at reasonable cost

(4) LEGISLATION

Discussing public health services the Supreme Court Justice John M Harlan observed that it is the settled doctrine of this court that as a Government is organised for the purpose among others of preserving the public health and public morals it cannot divest itself of the responsibility of providing these objects ' Consolidated laws must be enacted and enforced to ensure that health rules laid down by the experts are carried out

(5) FUNDS

Local bodies have neither the resources nor the money to finance malaria control scheme on a large scale They may be able to meet only a small portion of the expenses the rest will have to be shared between the States and the Central Government The Central Malaria Control Organisation should be allotted necessary funds and should have the powers to allot money to the States according to their respective requirements There is no doubt that in the beginning expenses will be high but every rupee spent will mean thousands of rupees saved together with the preservation of thousands of lives and the prevention of the untold miseries endured by malaria sufferers No price is too great for ensuring public health security The inter departmental committee to co ordinate health and welfare activities (a co ordination which is an essential part of any health programme) in the U S A observed in their report for 1939 It is the conviction of the Committee derived from experience that at the present time there is no greater public need from the standpoint of individual and social security than a comprehensive programme to safeguard a nation s health It is an observation which is true for any part of the world

REFERENCES

GRANT J B (1944) *Health of India* Oxford University Press Bombay

KRISHNAN K V (1940) *Bengal Public Health Journal* 2, 1

APPENDIX 1

MALARIA*

INTRODUCTION

1 Malaria is by far the most important disease in India from the point of view of sickness and mortality Lieut Colonel J A Sinton a malariologist of international reputation and a former Director of the Malaria Institute of India has estimated that at least 100 million persons suffer from the disease every year in British India that because of its effect in lowering the vitality of its victims it is also responsible for morbidity from other causes in an additional 25 to 75 million persons annually and that directly and indirectly it is responsible for at least two million deaths each year

2 It is impossible to make any complete or accurate evaluation of all the losses for which malaria is responsible For instance it is difficult to assess the financial loss that the country suffers as the result of decreased productivity through the incidence of the disease Col Sinton has however estimated that on an admittedly incomplete but conservative basis the annual loss to the country measured in terms of money may be anywhere between Rs 147 crores and Rs 187 crores per year If all the relevant factors could be taken into consideration the loss is likely to be two or three times this estimate

3 A tragic feature of the situation is that much of the malaria prevalent in the populated areas of the country is man made In many case roads and railways have a sinister account to their credit Their embankments often cause such interference with natural drainage as to create conditions favourable to the breeding of the malaria-carrying types of mosquitoes while borrow pits which follow the line of our roads and railways help to provide additional breeding grounds Bengal is generally cited as an outstanding example of man s thoughtless interference with natural drainage resulting in the steady rise in the incidence of malaria over the greater part of that province The failure of irrigation engineers to provide for adequate drainage when water is brought into previously dry areas has been another fruitful cause of the spread of the disease Recent examples of this are to be found in certain areas in Sind the Province of Madras and Mysore The first question with which we are faced is whether the great drain on the national health and prosperity caused by malaria is unavoidable After the discovery by Sir Ronald Ross towards the close

* Extracts from the Report of the Health Survey & Development Committee 1946 Manager of Publications Delhi

of the last century that certain types of mosquitoes are the transmitters of malaria it has been demonstrated in limited areas in different parts of the world that the strict enforcement of anti mosquito measures can effectively control the incidence of the disease In the Panama Canal Zone the first attempt to construct the Canal was frustrated by the ravages among the workmen of two mosquito-borne diseases yellow fever and malaria When however radical antimosquito measures were enforced in this area these diseases were brought under complete control The introduction of effective antimalaria measures at Ismailia in the Suez Canal area and in Algeria was attended by equally convincing results In this country the Raipur Vizagapatam section of the B N Railway could not have been constructed had not malaria among the labour force been kept under control by an expert malariologist while the Mettur dam and the Sarda Canal afford other instances where large irrigation projects were successfully completed with the help of malaria control measures

In recent years even more effective preventive measures against malaria have become available including potent chemicals for the destruction of the mosquito and drugs for protecting man against repeated infection The remarkable manner in which the fighting forces of the Allies operating in highly malarious tracts have been protected against this scourge during the present war again bears testimony to the possibility of effectively controlling the disease It is clear to us that given the determination the money and the requisite staff it should be possible to reduce the incidence of the disease in India to small proportions

Antimalaria Measures

4 The measures that are necessary against malaria fall under two main heads namely (1) those which are directed against the *transmitter of infection the mosquito* and (2) those which deal with man in his twofold capacity as a victim of the disease and as a reservoir of infection Antimosquito measures may be grouped under the following heads —

(*i*) those which control the breeding of the mosquito and
(*ii*) those which are directed against the insect in its adult form

5 *Measures to control the breeding of mosquitoes*—These measures take a wide variety of forms although the main principles involved are the same viz the obliteration of facilities for the laying of eggs by the female mosquito and the creation of conditions inimical to the survival of the insect in its larval stage in circumstances when egg laying cannot be prevented The steps that are necessary for these purposes include among others drainage to prevent accumulations of water canalisation of water channels and the removal of vegetation from their sides the use of larvicides such as mineral oils paris green and the more recent

synthetic product D D T selective clearing of jungle or shading of water courses in certain cases and the use of larvivorous fish

6 There are many varieties of fish in this country which prey on mosquito larvae Gambusia an American species of minnow introduced into India about twenty years ago is being used in the wells in Bangalore and Bombay the ornamental waters in Delhi and in many other parts of the country This species has been proved to possess all the qualities required for anti mosquito work and is probably more suitable for this purpose than any other species It should be emphasised however that the value of fish is very limited They are useful in artificial collections of water like ornamental waters but their use is of doubtful value as a general antilarval measure

7 For dealing with the malarial conditions created by large constructional works and irrigation projects well planned schemes requiring considerable technical supervision and heavy expenditure will be necessary These can obviously be undertaken and carried out only by the State On the other hand in many parts of the rural areas effective results may be secured by works of a minor nature such as the filling up of pools and ditches so as to prevent collections of water or other measures already mentioned such as oiling removal of vegetation etc In our short term programme we have made certain suggestions for the carrying out of such measures in rural areas We have provided for a small labour force of 15 in each primary unit one of whose duties will be to see to the carrying out of these minor works These men may be unable to deal effectively with the whole area covered by such a unit but an important part of their work will lie in their being able as a trained group to demonstrate to the villagers how to go about these tasks properly We hope that the village Committees we have recommended (vide Chapter IV) will be able to mobilise voluntary local effort in carrying out such measures and that we shall thus be able to enlist a tremendous force in the fight against this disease The small labour squad will also form the nucleus round which during an epidemic an expanded organisation can be rapidly built up

8 It is desirable that the planning and execution of these antimalarial works should as far as possible receive technical guidance and we have recommended the appointment of an Assistant Public Health Engineer at the headquarters of each secondary unit for this purpose Direct local supervision will be provided by the medical officer in charge of the primary unit and his two public health inspectors

9 Although we hope that the local effort we have referred to will help to reduce the cost of labour sufficient public funds should be made available to ensure that the required expenditure will be fully met We have included in our budget for each primary unit a provision for meeting this expenditure

of the last century that certain types of mosquitoes are the trans mitters of malaria it has been demonstrated in limited areas in different parts of the world that the strict enforcement of anti mosquito measures can effectively control the incidence of the disease In the Panama Canal Zone the first attempt to construct the Canal was frustrated by the ravages among the workmen of two mosquito borne diseases yellow fever and malaria When however radical antimosquito measures were enforced in this area these diseases were brought under complete control The introduction of effective antimalaria measures at Ismailia in the Suez Canal area and in Algeria was attended by equally convinc ing results In this country the Raipur Vizagapatam section of the B N Railway could not have been constructed had not malaria among the labour force been kept under control by an expert malariologist while the Mettur dam and the Sarda Canal afford other instances where large irrigation projects were success fully completed with the help of malaria control measures

In recent years even more effective preventive measures against malaria have become available including potent chemicals for the destruction of the mosquito and drugs for protecting man against repeated infection The remarkable manner in which the fighting forces of the Allies operating in highly malarious tracts have been protected against this scourge during the present war again bears testimony to the possibility of effectively controlling the disease It is clear to us that given the determination the money and the requisite staff it should be possible to reduce the incidence of the disease in India to small proportions

ANTIMALARIA MEASURES

4 The measures that are necessary against malaria fall under two main heads namely (1) those which are directed against the transmitter of infection the mosquito and (2) those which deal with man in his twofold capacity as a victim of the disease and as a reservoir of infection Antimosquito measures may be grouped under the following heads —

(i) those which control the breeding of the mosquito and
(ii) those which are directed against the insect in its adult form

5 *Measures to control the breeding of mosquitoes*—These measures take a wide variety of forms although the main princi ples involved are the same viz the obliteration of facilities for the laying of eggs by the female mosquito and the creation of conditions inimical to the survival of the insect in its larval stage in circumstances when egg laying cannot be prevented The steps that are necessary for these purposes include among others drainage to prevent accumulations of water canalisation of water channels and the removal of vegetation from their sides the use of larvicides such as mineral oils paris green and the more recent

synthetic product D D T selective clearing of jungle or shading of water courses in certain cases and the use of larvivorous fish

6 There are many varieties of fish in this country which prey on mosquito larvae Gambusia an American species of minnow introduced into India about twenty years ago is being used in the wells in Bangalore and Bombay the ornamental waters in Delhi and in many other parts of the country This species has been proved to possess all the qualities required for anti mosquito work and is probably more suitable for this purpose than any other species It should be emphasised however that the value of fish is very limited They are useful in artificial collections of water like ornamental waters but their use is of doubtful value as a general antilarval measure

7 For dealing with the malarial conditions created by large constructional works and irrigation projects well planned schemes requiring considerable technical supervision and heavy expenditure will be necessary These can obviously be undertaken and carried out only by the State On the other hand in many parts of the rural areas effective results may be secured by works of a minor nature such as the filling up of pools and ditches so as to prevent collections of water or other measures already mentioned such as oiling removal of vegetation etc In our short term programme we have made certain suggestions for the carrying out of such measures in rural areas We have provided for a small labour force of 15 in each primary unit one of whose duties will be to see to the carrying out of these minor works These men may be unable to deal effectively with the whole area covered by such a unit but an important part of their work will lie in their being able as a trained group to demonstrate to the villagers how to go about these tasks properly We hope that the village Committees we have recommended (vide Chapter IV) will be able to mobilise voluntary local effort in carrying out such measures and that we shall thus be able to enlist a tremendous force in the fight against this disease The small labour squad will also form the nucleus round which during an epidemic an expanded organisation can be rapidly built up

8 It is desirable that the planning and execution of these antimalarial works should as far as possible receive technical guidance and we have recommended the appointment of an Assistant Public Health Engineer at the headquarters of each secondary unit for this purpose Direct local supervision will be provided by the medical officer in charge of the primary unit and his two public health inspectors

9 Although we hope that the local effort we have referred to will help to reduce the cost of labour sufficient public funds should be made available to ensure that the required expenditure will be fully met. We have included in our budget for each primary unit a provision for meeting this expenditure

circumstances a course of plasmoquine treatment following medication for curing an attack should be advocated as tending to reduce the chance of infection being conveyed to mosquitoes

Anti Malaria Organisations at the Centre and in the Provinces

16 In an article entitled The public health aspect of malaria control in the *Indian Medical Gazette* of December 1942 Major-General G Covell I M S Director Malaria Institute of India made the following observations —

An essential preliminary to the successful control of malaria in India is the formation of an adequately staffed permanent malaria organisation in each province the activities of which should be linked up with those of the central organisation of the Government of India

17 We fully endorse this view One of the great defects of the anti malaria campaign in India during the past 50 years was that it consisted of a series of spasmodic attempts to control the disease This lack of continuity of effort accompanied as it often was by the employment of an organisation with insufficient staff and equipment has been largely responsible for the inadequacy of the results achieved As we have already said it has been amply demonstrated during the present War that with adequate measures even the highly malarious regions of the Tropics can be rendered comparatively safe from this disease Again we have pointed out in our review of existing conditions how the malaria organisation which has been working in the Delhi urban area for the past seven or eight years has shown that under civil conditions also a reasonably effective control of the incidence of the disease can be achieved provided adequate funds are *expended under the best available technical advice* In these circumstances we feel that there can be no excuse for Governments in this country not attempting to organise an effective campaign against the disease Its wide prevalence the cost involved and the existing inadequacy of trained personnel may result in this campaign being extended over perhaps many years Even so it is most important that a beginning should be made and in the following paragraphs specific proposals are made towards this end

18 *Central Malaria Organisation* The Malaria Institute of India is the central organisation for advising the Government of India on all matters relating to this disease as well as for assisting Provincial Governments with such technical advice as they may require Its functions have been defined by the Director of Malaria Institute in the following terms —

1 To be fully informed upon all malaria problem To advise Government on all issues relative to malaria in India

2 To initiate enquiries and investigations on malaria To carry out such inquiries as Government may for any reason require To assist provincial organisations in the carrying out of such inquiries as may be under taken by them providing such assistance as desired and even in certain cases when thought necessary to lend officers temporarily from the staff to work under local government

3 To undertake systematic research in due course into all the basic facts underlying malaria transmission prevalence and prevention such as the study of mosquitoes systematic and bionomical types of malaria parasites transmission power of different species of Anopheles mechanism of infection including the study of endemic and epidemic phenomena etc Gradually to complete and organise knowledge on these subjects and to arrange for the making of such knowledge available for practical application or such other uses as may be desirable

4 To carry out epidemiological investigations—mapping of endemicity study of hyperendemic and healthy areas study of malaria statistics on modern lines—and generally to elucidate the underlying principles of malaria prevalence in India

5 To advise upon and assist in the carrying out of anti malaria measures To study these scientifically and to judge and elucidate their results

6 To undertake clinical work on malaria including treat ment To study serum reactions and allied aids to diagnosis and understanding the disease To study relapse problems effects of new drugs etc

7 To assist affiliated researches (e g kalaazar filariasis sandfly fever dengue Stegomyia work) by identifica tion of material provision of trained staff and subordi nate personnel

8 To teach and train officers and others in practical malaria work

9 To publish scientific results useful guides bulletins etc

10 To keep alive interest in malaria study and prevention and to see that such interest wherever present is nursed and assisted

We are in full agreement with the Director that these should be the main function of the Malaria Institute of India

The permanent establishment of the Institute consists of a Director an Assistant Director an Entomologist an Assistant to the Director a Malaria Assistant and appropriate subordinate staff The new posts of a Deputy Director an Assistant D

and of certain subordinate staff which were recently created as a temporary measure for the duration of the war should be made permanent In view of the large developments that are likely to take place in the activities of this malaria organisation the Central Health Department should bear in mind the importance of ensuring that it is adequately staffed

19 *The provincial malaria organisation*—The general plan should be the creation of an organisation at the headquarters of each province and in addition a number of malaria control units to operate in malarious areas in the districts The number of these units will obviously depend upon the size of the province and the extent and degree of the prevalence of malaria in it As an illustration we may set out a plan for the province of Bengal We think that about 150 such units will eventually be required for that province but a beginning may be made with ten Others can be added as and when additional trained staff and funds become available But it is essential that even from the beginning suitable transport should be provided for these control units in order to increase their mobility and effectiveness

In the larger provinces it will be necessary to provide regional organisations also in order to ensure that adequate supervision is exercised over the peripheral malaria control units In the smaller provinces however such regional organisations may not be necessary Here the Provincial Malaria Officers and their staff should be able to carry out the necessary supervision This Provincial Officer should have the status of an Assistant Director of Health Services and the Regional Malaria Officers may be designated Deputy Malaria Officers

The complete organisation for a large province such as Bengal may be developed on the following lines —

1	Provincial Headquarters—	
	Provincial Malaria Officer	1
	Entomologist	1
	Sanitary Engineer	1
	Overseers	4
	Draftsman	1
	Antimalaria Officer	1
	Antimalaria Assistants	2
	Laboratory Assistants	5
	Insect Collectors	8
2	Deputy Malaria Officers	5
3	Malaria Control Units—	
	Antimalaria Assistant	1
	Laboratory Assistants	2
	Malaria Supervisors	5
	Fitter Mistri	1
	Field Workers	15

Antimalarial field workers are semi skilled labourers and should not be considered as coolies

Lists of suitable equipment for the malaria organisation at the provincial headquarters and for the malaria control units are given in Appendix 14 of Volume III* of the report

These estimates of the malaria organisation desirable for a province such as Bengal including staff and equipment were prepared for us by the Director of the Malaria Institute of India He has suggested the following approximate number of malaria control units for the different provinces

	No of control units		*No of control units*
Madras	100	N W F Province	30
Bombay	60	Sind	60
Bengal	150	Ajmer Merwara	5
United Provinces	150	Baluchistan	30
Punjab	60	Delhi Province	2
Bihar	100	Coorg	5
Orissa	50		
Central Provinces & Berar	100		982
Assam	80		

He has stated that in calculating these requirements he took into account such factors in respect of each province as the area population number of districts number of villages and the degree of prevalence of malaria as indicated by (a) statistics of malaria mortality and (b) the percentage of fever cases on total cases treated at hospitals and dispensaries

20 In our view the most essential requirements are adequately trained personnel in sufficient numbers and the drugs appliances and other equipment for carrying on effectively the campaign against the disease We would as a general rule deprecate the spending of large sums on the erection of elaborate buildings in the early stages of our programme for we believe that such money as is likely to be available can at the beginning be much more effectively used on staff and antimalarial measures

21 We once again feel it necessary to stress the inestimable value of good rural communications in increasing the effectiveness of all health and other workers employed on nation building tasks in such areas

22 For details regarding the staff required for such an organisation reference may be made to Appendix 14 The total expenditure involved in the development of malaria organisations

Appendix I(a)

28 We wish to make it clear that these recommendations of ours for concentrating the training of the higher type of malaria personnel at Delhi are of a purely temporary nature. When the antimalaria organisations in the provinces become fully developed the provision of training facilities for all types of malaria workers should in our view be the responsibility of Provincial Governments We have suggested later in this chapter the creation of Chairs of Malariology in selected medical colleges in order to provide facilities for undergraduate and postgraduate training in the subject as well as for stimulating research Thus the provinces should in due course develop facilities for the highest type of training that may be required in Malariology

Quinine and other Drugs for the Treatment of Malaria

29 We have already referred to the use of quinine and mepacrine for the treatment of malaria It is possible that other drugs of greater therapeutic value may also be discovered as the result of scientific research It is therefore not easy to estimate accurately what levels of production in India should be recommended for the immediate future in respect of quinine and mepacrine in order to ensure that proper treatment facilities are made available to a substantial proportion of the sufferers from malaria All of us are however agreed that it should be the responsibility of Governments Central and Provincial to take in mutual consultation such steps as are necessary to ensure the production in India of antimalaria drugs in sufficient quantities to meet the requirements of the country within the shortest possible period We are equally agreed that the country should not again be placed at the mercy of a private monopoly which can control to its own advantage the price of these drugs which are essential for the maintenance of the health of the people Whether in making adequate provision for these drugs Governments should themselves undertake extensive programmes of production or whether private enterprise can be relied on to supply the needs of the country through any system of guarantees or subsidies from the State are matters on which we are unable to express an opinion with the information at our disposal We can only lay down three general propositions —

(1) the prices at which antimalaria drugs are made available to the people should be sufficiently low to enable the poorest classes to obtain them in adequate amounts for the effective treatment of the disease

(2) these drugs in whatever provinces they may be produced should be made available on an equitable basis and on reasonable terms for the needs of all parts of the country and

(3) no delay should be allowed to occur in developing their production

We shall first consider the production of quinine

30 (a) *Quinine*—If Colonel Sinton s estimate that at least one hundred million individuals suffer from the disease every year be taken as the basis of calculation it does not seem unreasonable to assume that there will be at least 120 to 150 million cases to be treated annually in view of the fact that more than one attack is not an uncommon feature of the disease The Malaria Commission has recommended 75 grains of quinine as the minimum quantity necessary for the treatment of a case On this basis the amount of quinine required will be in the neighbourhood of 1 3 to 1 6 million pounds per year If quinine is to be relied upon as the sole drug for the treatment of malaria our objective should be an annual production of it to the extent of about 1 5 million pounds from cinchona bark produced in the country Some of us hold the view that this should be the definite objective which Governments should place before themselves and that every endeavour should be made to attain it within the shortest period that may be practicable Others feel that the experience gained during the War with the large scale use of mepacrine in the treatment and prevention of malaria in highly endemic areas makes it necessary to take into account the possibility of this drug replacing quinine to a greater or less extent in the treatment of the disease and that it would in the circumstances be safer to start with a more limited objective in regard to the production of quinine The average annual consumption of quinine in India in the pre war period was 210 000 lbs and of this amount about a third was produced in India a part of such production being we believe from bark imported from Java As a practical objective for realisation as early as possible those of us who hold this view recommend the raising of quinine production to the pre war level of consumption in India namely about 210 000 lbs from indigenous bark alone A cinchona plant begins to yield bark generally from the fifth year of its life the period of high productivity being from the fifth to the ninth year After the twelfth year its yield gradually decreases In these circumstances the raising of the annual production of quinine even to 210 000 lbs mark from bark produced in the country will take some years In the meantime the possibility of synthetic drugs displacing quinine wholly or in part in the treatment of malaria may well be settled This is a question of considerable importance which should be decided before embarking on too ambitious a programme of quinine production Such a programme is certain to involve heavy financial commitments which would not be justified if it became possible to produce cheaper and equally effective synthetic substitutes

31 We as a committee would prefer to leave to the Govern

ments in the country the responsibility for deciding whether private enterprise should or should not be associated with the production of quinine and of other antimalaria drugs If it is decided that such association is desirable it would be for Governments to determine the conditions under which private agencies should participate in production One of us (Sir Frederick James) however desires to see that private agencies are given the fullest opportunity to take part in quinine production with technical advice and a price guarantee provided by the State We attach our colleague's note on the subject We fully support his suggestion that research into the agricultural and manufacturing aspects of the quinine industry should be a governmental responsibility and that two experimental stations should be established to serve North and South India respectively

32 (*b*) *Mepacrine*—The pre war annual consumption figure of 210 000 lbs of quinine will provide treatment at the rate of 75 grains per patient for about 19 6 or nearly 20 million cases of malaria If as an immediate objective, we accept the provision of adequate antimalaria drugs for the treatment of 50 million cases annually then sufficient mepacrine will have to be produced to meet the requirements of 30 million patients The minimum quantity of this drug for a complete course for a patient is 1 5 grammes or 15 tablets of 0 1 gramme each The manufacture of 450 million tablets of mepacrine a year in India should therefore be the immediate objective

33 *Pyrethrum and D D T*—The main sources of pyrethrum before the War were Kenya and Japan but the cultivation of the plant has been successfully undertaken in various parts of India including Kashmir the Punjab Hills the U P Central Provinces Madras and Orissa It has been shown that the yield of the active principle from the plants grown in many parts of India compares favourably with the flowers obtained from Kenya In these circumstances it may be reasonably expected that in the course of some years there will be an ample supply of pyrethrum grown in this country to meet all local demands The Director Malaria Institute of India has estimated that in order to make the country self-sufficient pyrethrum cultivation will have to be extended to about 120 000 acres so as to produce annually about 15 000 short tons (2 000 lbs a ton) of pyrethrum flowers This estimate makes allowance for a sixth of the total area under cultivation lying fallow each year

34 *As an insecticide the relationship of D D T to pyrethrum is somewhat similar to that of mepacrine to quinine in the treatment of malaria* There is the possibility in both cases of the synthetic substance replacing to a greater or less extent the use of the other It may however be pointed out that the indiscriminate use of D D T has been shown to result in the destruction of certain types of beneficial insects It is quite likely that in

due course adequate safeguards will be discovered and introduced in order to prevent these detrimental effects There is also the possibility that insecticides more potent than D D T may be produced and brought into use While recognising that these possibilities should be given due weight we think that the cultivation of pyrethrum in India should be developed until the use of D D T has become established Even when this stage is reached the production of a certain amount of pyrethrum will still be necessary if as has been suggested a combination of D D T and pyrethrum is more effective than either of them alone Another reason which has prompted us to advocate the continuance of its cultivation is that at short notice it can if necessary be given up and replaced by other crops Here again the steps required to foster the increased growth of pyrethrum must be decided by Governments after a full examination of the relevant factors

We can only stress the necessity for a largely increased supply of pyrethrum flowers at a reasonable price and the duty of Governments in India to take immediate steps to ensure production on a scale sufficient for the needs of the country

35 *Clinical Research in Malaria*—While one line of attack in the malaria problem is through the control of the carrier types of mosquitoes another should be directed towards the elimination of the reservoirs of infection As relapses are quite common in malaria a person who suffers from an attack of the disease continues *in an appreciable percentage of cases* to harbour the parasite for a varying length of time The complete destruction of all the parasites in such persons should form an important part of an antimalarial campaign One of the limitations of all antimalarial drugs so far available (including quinine mepacrine and plasmoquine) is that they help to kill only such of the parasites as are present in the circulating blood of the patient while those which are harboured in the spleen and other internal organs escape The achievements of chemotherapy have during recent years been so brilliant that it is quite conceivable that a drug may be discovered with power to kill the parasite not only in the circulating blood but also in those internal organs in which it finds refuge Any such drug when discovered and tested in the laboratory can be considered to be effective only by a reasonably large field trial on human beings We feel that there is need for the active promotion of combined biochemical and clinical research aiming at the evolution of a suitable drug which will help not only to cure the patient for the time being but also to destroy the parasites in him completely

36 We consider the promotion of active research in malaria to be of fundamental importance in this country The creation of Chairs of Malariology in selected medical colleges is a highly desirable step *in this connection* These professorships would serve a

double purpose namely the fostering of research in malaria and the provision of adequate facilities for undergraduate and post graduate training in the subject

37 *Legislation*—The effective enforcement of antimosquito measures requires suitable legislation and we have given as appendices 15 16 and 17* respectively the Model Mosquito Ordinance of the United States Public Health Service the Straits Settlements Destruction of Mosquitoes Ordinance No 174 and those sections of the Bombay City Municipal Act which deal with anti mosquito measures in order that they may be examined by the different health authorities in the country with a view to seeing how far they may be followed as models

Certain Suggestions by Sir Frederick James O B E M L A for Increasing Quinine Production

38 (1) Before deciding on the method of increasing the production of cinchona bark in India it would be well to study the production methods in the Netherlands East Indies which before the War supplied over 90 per cent of the world s quinine Their dominating position has been achieved through a combination of Government and private efforts and the systematic way in which the industry has been organised

(2) Nine tenths of the cinchona produced in the N E Indies comes from private plantations but the improved types of cinchona and the improved methods of cultivation and propagation are derived from the work carried out at the Government cinchona plantations Judged by ordinary standards of commercial accountancy the production of cinchona on private estates will always be cheaper than on Government estates If therefore the aim is to produce quinine at as reasonable a cost as possible every attempt should be made to persuade planters to take up its cultivation

(3) A Central Cinchona Bureau for India similar to the Kina Bureau of the Netherlands East Indies should be established Such a Bureau might well have two experimental stations one situated in the North and the other situated in the South with plantations attached If such a Bureau were placed under the Imperial Council of Agricultural Research and private planters were associated with it India would have taken the first step towards raising cheap cinchona for the only bark which is really cheap is the bark of the high yielding types

(4) The main work on both these experimental stations would be the *study of plant breeding vegetative propagation* cultivation manuring and the regeneration of plantations which had already finished one cycle of cinchona growing

* Appendices I (*b*) (*c*) and (*d*)

(5) One of the reasons why cinchona production has been so backward in India is its provincialization in Madras and Bengal the lack of an all India policy and the failure of the Governments concerned either to associate experienced planters with the development of their stations or to encourage private enterprise

(6) On page 153 there are two general propositions —

(a) That the prices at which antimalaria drugs including quinine are made available to the people should be sufficiently low to enable the poorest classes to obtain them in adequate amounts for the effective treatment of the disease This will involve a certain amount of price control and in the event of private plantations being encouraged profit control also But the planting of cinchona is a risky enterprise and if profits are to be controlled in order to ensure that the price of quinine is kept at a reasonably low level then a guaranteed offtake at a fixed price is the only inducement which will encourage private enterprise The world price of cinchona has fluctuated around Rs 20 per lb and the experience of the Netherlands East Indies has shown that a reasonably profitable industry can be a sound basis for a normal and constant production This should be recognised by those who wish to see quinine provided at a cheap price for it can only be achieved if economy is effected in the costs of production and distribution by efficient management or funds are provided from public revenues to meet the loss incurred by inefficient production Costs of production can be reduced by scientific research and efficient organisation and of this industry is well aware

(b) That no delay should be allowed to occur in starting new plantations on an adequate scale If a Central Cinchona Bureau is established it should be fairly simple to plan production with a view both to ensuring supplies of bark to existing factories and where new areas are being opened up for the maintenance of other factories in full production

Government stations should also assist by raising plants of good quality for sale to private growers Sales would be partly adjusted to the cinchona which they desired to establish in any areas

The cinchona industry should be essentially an all India concern but at present it is provincial and dealt with by two provincial Governments If the price guarantee is agreed to by the Central Government then it could be made conditional on a certain amount of control over policy both of extensions and scientific research. If the Madras and the Bengal Governments are not prepared to associate the Imperial Council of Agricultural Research with the planning of the work at their stations then the Central Government should establish its own research station in Coorg which is a centrally administered area and is suitable for plantation of cinchona

double purpose namely the fostering of research in malaria and the provision of adequate facilities for undergraduate and post graduate training in the subject

37 *Legislation*—The effective enforcement of antimosquito measures requires suitable legislation and we have given as appendices 15 16 and 17* respectively the Model Mosquito Ordinance of the United States Public Health Service the Straits Settlements Destruction of Mosquitoes Ordinance No 174 and those sections of the Bombay City Municipal Act which deal with antimosquito measures in order that they may be examined by the different health authorities in the country with a view to seeing how far they may be followed as models

Certain Suggestions by Sir Frederick James O.B.E. M.L.A. for Increasing Quinine Production

38 (1) Before deciding on the method of increasing the production of cinchona bark in India it would be well to study the production methods in the Netherlands East Indies which before the War supplied over 90 per cent of the world s quinine Their dominating position has been achieved through a combination of Government and private efforts and the systematic way in which the industry has been organised

(2) Nine-tenths of the cinchona produced in the N E. Indies comes from private plantations but the improved types of cinchona and the improved methods of cultivation and propagation are derived from the work carried out at the Government cinchona plantations. Judged by ordinary standards of commercial accountancy the production of cinchona on private estates will always be cheaper than on Government estates. If, therefore the aim is to produce quinine at as reasonable a cost as possible every attempt should be made to persuade planters to take up its cultivation

(3) A Central Cinchona Bureau for India similar to the Kina Bureau of the Netherlands East Indies should be established Such a Bureau might well have two experimental stations, one situated in the North and the other situated in the South with plantations attached If such a Bureau were placed under the Imperial Council of Agricultural Research and private planters were associated with it, India would have taken the first step towards raising cheap cinchona for the only bark which is really cheap is the bark of the high yielding types.

(4) The main work on both these experimental stations would be the study of plant breeding vegetative propagation cultivation, manuring and the regeneration of plantations, which had already finished one cycle of cinchona growing

* Appendices I (b) ( ) and (d)

(5) One of the reasons why cinchona production has been so backward in India is its provincialization in Madras and Bengal the lack of an all India policy and the failure of the Governments concerned either to associate experienced planters with the development of their stations or to encourage private enterprise

(6) On page 153 there are two general propositions —

(a) That the prices at which antimalaria drugs including quinine are made available to the people should be sufficiently low to enable the poorest classes to obtain them in adequate amounts for the effective treatment of the disease This will involve a certain amount of price control and in the event of private plantations being encouraged profit control also But the planting of cinchona is a risky enterprise and if profits are to be controlled in order to ensure that the price of quinine is kept at a reasonably low level then a guaranteed offtake at a fixed price is the only inducement which will encourage private enterprise The world price of cinchona has fluctuated around Rs 20 per lb and the experience of the Netherlands East Indies has shown that a reasonably profitable industry can be a sound basis for a normal and constant production This should be recognised by those who wish to see quinine provided at a cheap price for it can only be achieved if economy is effected in the costs of production and distribution by efficient management or funds are provided from public revenues to meet the loss incurred by inefficient production Costs of production can be reduced by scientific research and efficient organisation and of this industry is well aware

(b) That no delay should be allowed to occur in starting new plantations on an adequate scale If a Central Cinchona Bureau is established it should be fairly simple to plan production with a view both to ensuring supplies of bark to existing factories and where new areas are being opened up for the maintenance of other factories in full production

Government stations should also assist by raising plants of good quality for sale to private growers Sales would be partly adjusted to the cinchona which they desired to establish in any area

The cinchona industry should be essentially an all India concern but at present it is provincial and dealt with by two provincial Governments If the price guarantee is agreed to by the Central Government then it could be made conditional on a certain amount of control over policy both of extensions and scientific research If the Madras and the Bengal Governments are not prepared to associate the Imperial Council of Agricultural Research with the planning of the work at their stations then the Central Government should establish its own research station in Coorg which is a centrally administered area and is suitable for plantation of cinchona

double purpose namely the fostering of research in malaria and the provision of adequate facilities for undergraduate and post graduate training in the subject

37 *Legislation*—The effective enforcement of antimosquito measures requires suitable legislation and we have given as appendices 15 16 and 17* respectively the Model Mosquito Ordinance of the United States Public Health Service the Straits Settlements Destruction of Mosquitoes Ordinance No 174 and those sections of the Bombay City Municipal Act which deal with antimosquito measures in order that they may be examined by the different health authorities in the country with a view to seeing how far they may be followed as models

CERTAIN SUGGESTIONS BY SIR FREDERICK JAMES O B E M L A FOR INCREASING QUININE PRODUCTION

38 (1) Before deciding on the method of increasing the production of cinchona bark in India it would be well to study the production methods in the Netherlands East Indies which before the War supplied over 90 per cent of the world s quinine Their dominating position has been achieved through a combination of Government and private efforts and the systematic way in which the industry has been organised

(2) Nine tenths of the cinchona produced in the N E Indies comes from private plantations but the improved types of cinchona and the improved methods of cultivation and propagation are derived from the work carried out at the Government cinchona plantations Judged by ordinary standards of commercial accountancy the production of cinchona on private estates will always be cheaper than on Government estates If therefore the aim is to produce quinine at as reasonable a cost as possible every attempt should be made to persuade planters to take up its cultivation

(3) A Central Cinchona Bureau for India similar to the Kina Bureau of the Netherlands East Indies should be established Such a Bureau might well have two experimental stations one situated in the North and the other situated in the South with plantations attached If such a Bureau were placed under the Imperial Council of Agricultural Research and private planters were associated with it India would have taken the first step towards raising cheap cinchona for the only bark which is really cheap is the bark of the high yielding types

(4) The main work on both these experimental stations would be the study of plant breeding vegetative propagation cultivation manuring and the regeneration of plantations which had already finished one cycle of cinchona growing

* Appendices I (*b*) (*c*) and (*d*)

(5) One of the reasons why cinchona production has been so backward in India is its provincialization in Madras and Bengal the lack of an all India policy and the failure of the Governments concerned either to associate experienced planters with the development of their stations or to encourage private enterprise

(6) On page 153 there are two general propositions —

(a) That the prices at which antimalaria drugs including quinine are made available to the people should be sufficiently low to enable the poorest classes to obtain them in adequate amounts for the effective treatment of the disease This will involve a certain amount of price control and in the event of private plantations being encouraged profit control also But the planting of cinchona is a risky enterprise and if profits are to be controlled in order to ensure that the price of quinine is kept at a reasonably low level then a guaranteed offtake at a fixed price is the only inducement which will encourage private enterprise The world price of cinchona has fluctuated around Rs 20 per lb and the experience of the Netherlands East Indies has shown that a reasonably profitable industry can be a sound basis for a normal and constant production This should be recognised by those who wish to see quinine provided at a cheap price for it can only be achieved if economy is effected in the costs of production and distribution by efficient management or funds are provided from public revenues to meet the loss incurred by inefficient production Costs of production can be reduced by scientific research and efficient organisation and of this industry is well aware

(b) That no delay should be allowed to occur in starting new plantations on an adequate scale If a Central Cinchona Bureau is established it should be fairly simple to plan production with a view both to ensuring supplies of bark to existing factories and where new areas are being opened up for the maintenance of other factories in full production

Government stations should also assist by raising plants of good quality for sale to private growers Sales would be partly adjusted to the cinchona which they desired to establish in any areas

The cinchona industry should be essentially an all India concern but at present it is provincial and dealt with by two provincial Governments If the price guarantee is agreed to by the Central Government then it could be made conditional on a certain amount of control over policy both of extensions and scientific research If the Madras and the Bengal Governments are not prepared to associate the Imperial Council of Agricultural Research with the planning of the work at their stations then the Central Government should establish its own research station in Coorg which is a centrally administered area and is suitable for plantation of cinchona

Appendix I(b)

MODEL MOSQUITO ORDINANCE

United States Public Health Service

Section 1—It shall be unlawful for any person to have keep maintain cause or permit within the corporate limits of any collection of standing or flowing water in which mosquitoes breed or are likely to breed unless such collection of water is treated so as effectually to prevent such breeding

Section 2—Collections of water in which mosquitoes breed or are likely to breed are those contained in ditches ponds pools excavations holes depressions open cess-pools privy vaults fountains cisterns tanks shallow wells barrels troughs (except horse troughs in frequent use) urns cans boxes bottles tubs buckets defective house roof gutters tanks or flush closets or other water containers

Section 3—The natural presence of mosquito larvae in standing or running water shall be evidence that mosquitoes are breeding there

Section 4—Collections of water in which mosquitoes breed or are likely to breed shall be treated by such one or more of the following methods as shall be approved by the health officer—

(Here follows description of methods)

Section 5—In case the person responsible for the condition of premises on which mosquitoes breed or are likely to breed fails or refuses to take necessary measures to prevent their breeding within three days after notice in writing has been given him by the health officers or within such longer time after such notice as may be specified in the notice the said person responsible shall be deemed guilty of a violation of this ordinance and for each day after the expiration of three days from the day on which such notice is given him or for each day after the expiration of the time specified in the notice as the case may be that the person responsible fails or refuses to take such measures the said person responsible shall be deemed guilty of a separate violation of this ordinance and in case of such failure or refusal of the person responsible the health officer is authorised to take necessary measures to prevent the breeding of mosquitoes and all necessary costs incurred by the health officer for that purpose shall be a charge against the person responsible

Section 6—For the purpose of this ordinance the person responsible for the condition of any premises is the person using or occupying the same or in case no person is using or occupying the premises the person who by law is entitled to the immediate possession of the same or in case the premises are used or

occupied by two or more tenants of a common landlord each tenant however is responsible for that part of the premises which he occupies to the exclusion of the other tenants provided that in case the premises are occupied by a tenant under an yearly or monthly tenancy or under a lease for not more than a year or under any lease whereby the lessor is expressly or impliedly obligated to keep the premises in repair and the collection of standing or flowing water in which mosquitoes breed or are *likely to breed is owing to the disrepair of the building or buildings* or to any natural quality of the premises or to any conditions that existed at the time when the tenant entered into possession or to anything done on the premises by the landlord during the existence of the tenancy or lease then and in such case the landlord is the person responsible provided further that any person who has caused to exist on any premises of which he is not the owner landlord occupant or tenant any collection of water in which mosquitoes breed or are likely to breed is responsible as well as the owner landlord tenant or occupant as the case may be

Section 7 —For the purpose of enforcing the provisions of this ordinance the health officer or his lawful subordinate may at all reasonable times enter in and upon any premises within his jurisdiction

Section 8 —Any person found guilty of a violation of this ordinance as described in Section 5 hereof shall be punished by a fine of not less than one dollar ($ 1) and not more than twenty five dollars ($ 25)

Section 9 —This ordinance shall be in full force and effect on and after the ( ) *day from the day on which it is* approved

(*d*) to bring any water or swamp into a condition not favourable to the propagation or harbouring of mosquitoes

(*e*) to fill with concrete or otherwise treat hollows in trees which hold or are likely to hold water

7 Enforcement of order —(1) If the owner or occupier of any premises on whom an order under section 4 or 5 has been served fails to comply with the terms thereof the sanitary authority or any person authorised by him either generally or specially in that behalf in writing may enter upon or into the said premises with such assistants and things as are necessary and may perform and do thereon or therein all acts and things required by the said order to be performed or done and the cost thereof shall be recoverable from the owner or occupier by the sanitary authority

(2) If the amount of such costs is not paid by the party liable to pay the same within seven days after demand such amount may be reported to a Police Court and recovered in the same way as if it was a fine imposed by such Court

(3) Nothing in this section shall effect any liability of any person to prosecution and punishment under section 8

8 Penalty for default —(1) Any owner or occupier of any premises on whom an order under section 4 or 5 has been served who neglects to comply with the terms thereof shall be liable on conviction by a Police Court to a fine not exceeding five hundred dollars or to imprisonment of either description for a term which may extend to six months

(2) No person shall be punishable under this section for neglect to comply with any order in respect whereof he has appealed as hereinafter provided unless such order has been confirmed on appeal

10 Persons unable to meet necessary expenditure —If it appears to the sanitary authority after due inquiry that any person has not the means to meet the necessary expenses of doing any thing required to be done by him under this Ordinance such necessary expenses may be met from Municipal or Rural Board Funds as the case may be

11 No compensation —No person shall be entitled to compensation for any expense incurred or damage occasioned by any order given or act done in pursuance of this Ordinance or any rule made thereunder unless such damage has been occasioned maliciously or without reasonable cause

13 Penalty for obstructing sanitary authority —Any person who obstructs the sanitary authority or any person authorised by him or any person engaged in carrying out this Ordinance in any act authorised by this Ordinance shall be liable on conviction by a Police Court to a fine not exceeding two hundred dollars or to imprisonment of either description for a term which may extend to three months

14 Penalty for injuring works etc executed etc by sanitary authority —Any person who without the consent of the sanitary authority interferes with injures destroys or renders useless any works executed or any materials or things placed in under or upon any premises by or under the orders of the sanitary authority shall be liable on conviction before a Police Court to a fine not exceeding five hundred dollars and the sanitary authority may in addition recover from such person in the same manner as if it was fine imposed by a Police Court such costs and expenses as it incurs in re-executing the works or replacing the materials or things so interfered with injured destroyed or rendered useless

15 Duty of owner and occupier to protect works for destruction of mosquitoes —(1) Where the sanitary authority or any department of Government or the Municipality has constructed any works with the object of preventing the breeding of mosquitoes whether before or after the coming into force of this Ordinance the owner and the occupier of the premises on which such works stand shall prevent such premises being used in any manner whatsoever that is likely to cause or has caused the deterioration or to lessen the efficiency of such works

(2) Penalty —Where any such premises are used in such a manner as to lessen the full efficiency of such works the owner and the occupier of such premises shall subject to sub section (4) be liable on conviction before a Police Court to a fine not exceeding five hundred dollars and the sanitary authority may enter upon the premises and execute any necessary repairs or work thereon and recover from such person in the same manner as if it was fine imposed by a Police Court such costs and expenses as it thereby incurs

APPENDIX I(d)

ANTIMOSQUITO PROVISION IN THE BOMBAY MUNICIPAL ACT

Section 3 —Definition of terms —

*(i) Water work includes a lake stream spring pump reservoir cisterns tank duct whether covered or open sluice mainpipe culvert engine and any machinery land building or thing for supply or used for supplying water

(z) Nuisance includes any act omission place or thing which causes or is likely to cause injury danger annoyance or offence to the sense of sight smelling or hearing or which is or may be dangerous to life or injurious to health or property

(aa) Dangerous Disease means cholera and any endemic epidemic or infectious disease by which the life of man is endangered

Section 61 —Matters to be provided for by the Corporation —It shall be incumbent on the corporation to make adequate provision by any means of measures which is lawfully competent to them to use or take for each of the following matters namely

(d) The reclamation of unhealthy localities the removal of noxious vegetation and generally the abatement of all nuisances

(g) Measures for preventing and checking the spread of dangerous diseases

Section 64 —Special functions of the Commissioner —(3) subject whenever it is in this Act expressly so directed to the approval or sanction of the corporation or the standing committee and subject also to all other restrictions limitations and conditions imposed by this Act the entire executive power for the purpose of carrying out the provisions of this Act vests in the Commissioner

Section 68 —Municipal officers may be empowered to exercise certain of the powers of the Commissioner —(1) Any of the powers duties or functions conferred or imposed upon or vested in the Commissioner by any of the sections sub sections or clauses mentioned in sub section (2) may be exercised performed or discharged under the Commissioner s control and subject to his revision and to such conditions and limitations if any as he shall think fit to prescribe by any municipal officer whom the Commissioner generally or specially empowers in writing in this behalf and in each of the said sections sub-sections and clauses the word Commissioner shall to the extent to which any municipal officer is so empowered be deemed to include such officer

(2) The sections sub sections and clauses of this Act referred to in sub-section (1) are the following namely —

279 374 377 381 381A 488 489

Section 274—Provisions as to cisterns—(1) The Commissioner may whenever it shall appear to him to be necessary by written notice require that any premises furnished with a private water supply from any municipal water work shall within a reasonable period which shall be prescribed in the said notice be provided with a storage cistern of such size material quality and description and with such fittings and placed in such a position and with such means of access as he thinks fit

Section 279—Power to cut off private water supply or to turn off water.—(1) The Commissioner may cut off the connection between any municipal water work and any premises to which a private water supply is furnished by the corporation or turn off the water from such premises in any of the following cases namely —

(b) if the owner or occupier of the premises neglects within the period prescribed in this behalf in any notice given under sub-section (1) of section 274 to comply with any requisition made to him by the Commissioner regarding the provision of a storage-cistern or the means of access thereto provided that the Commissioner shall not take action without the sanction of the standing committee

Section 374—Power to inspect premises for sanitary purposes—The Commissioner may inspect any building or other premises for the purpose of *ascertaining the sanitary conditions* thereof (But see Section 488)

Section 377.—Neglected premises —If it shall appear to the Commissioner that any premises are overgrown with rank and noisome vegetation or are otherwise in an unwholesome or filthy condition or by reason of their not being properly enclosed are resorted to by the public for purposes of nature or are otherwise a nuisance to the neighbouring inhabitants the Commissioner may by written notice require the owner or occupier of such premises to cleanse clear or enclose the same or with the approval of the standing committee may require him to take such other order with the same as the Commissioner thinks necessary

Section 381—Filling in of pools etc which are a nuisance —(i) *if in the opinion of the Commissioner*—

(a) any pool ditch tank well pound quarryhole drain watercourse or any collection of water or

(b) any cistern receptacle for water or any article or thing capable of containing water whether or not such cistern or receptacle article or thing contains water and is within or outside a building or

(c) any land on which water accumulates or is likely to accumulate or

(d) any premises or part of any premises occupied or unoccupied or under construction reconstruction or demolition is

or is likely to become a breeding place of mosquitoes or which is in other respects a nuisance as defined in clause (z) of section 3

(ii) The Commissioner may by notice in writing require the person by whose act default or sufferance a nuisance arises exists or continues or is likely to arise and the owner lessee or occupier of the land building or premises on which the nuisance arises exists or continues or is likely to arise or any one or more of such person owner lessee and occupier to remove discontinue or abate the nuisance by taking such measures and by executing such work in such manner with such materials as the Commissioner shall prescribe in such notice

(iii) The Commissioner may also by any notice under clause (ii) or by another notice served on such person owner lessee and occupier or on any one or more of them require them or any one or more of them to take all steps requisite or necessary to prevent a recurrence of the nuisance and may if he thinks it desirable specify any work to be executed or measures to be carried out for that purpose and may serve any further such notice notwithstanding that the nuisance may have been abated or removed if he considers that it is likely to recur

Provided that if at any time within six months from the date of the service of any such notice the nuisance recurs through the failure of the person or persons upon whom such notice has been served to comply with the requirements contained in such notice such person or persons shall be liable without any further notice to the penalties provided in this Act for offences under this section

(iv) Where the nuisance arises or exists or is likely to arise or recur in connection with the construction reconstruction or demolition of any premises or part of any premises the Commissioner may in addition to serving any notice on any one or more of the persons mentioned in clause (ii) serve any such notice on any architect contractor or other persons employed to carry out such work of construction reconstruction or demolition and also on any sub-contractor employed by such contractor or other person or any one or more of such contractor person and sub-contractor

Section 381 A.—Permission for new well etc —(1) No new well tank pond cistern or fountain shall be dug or constructed without the previous permission in writing of the Commissioner

(2) If any such work is begun or completed without such permission the Commissioner may either—

(a) by written notice require the owner or other person who has done such work to fill up or demolish such work in such manner as the Commissioner shall prescribe or

(b) grant written permission to retain such work but such permission shall not exempt such owner from proceedings for contravening the provisions of sub-section (1)

Section 461.—By laws for what purposes to be made.—The

corporation may from time to time make by laws not inconsistent with this Act with respect to the following maters namely —

(a) regulating in any particular not specifically provided for in this Act the construction maintenance and control of drains ventilation shafts or pipes cess-pools water-closets privies latrines urinals drainage works of every description whether belonging to the corporation or to other persons municipal water works private communication pipes and public streets

(b) regulating all matters and things connected with the supply and use of water

Section 471 —Certain offences punishable with fine —Whoever
(a) contravenes any provision of any of the sections sub-sections or clauses mentioned in the first column of the following table or of any regulation made thereunder or
(b) fails to comply with any requisition lawfully made upon him under any of the said sections sub-sections or clauses
shall be punished for each such offence with fine which may extend to the amount mentioned in that behalf in the third column of the said table

Section sub section or clause	Subject	Fine which may be imposed
		Rs
Section 274	Requisition to provide storage other fittings to be used for con nections with water works	50
Section 377	Requisition to cleanse etc neg lected premises	50
Section 381	Requisition to fill in pools etc which are a nuisance	50
Section 381 A subsection (1)	Digging or constructing well etc without permission	500
Section 381 A subsection (2)	Requisition to fill in or demolish well etc	500

Section 472 —Continuing offences —Whoever after having been convicted of—

(a) contravening any provision of any of the sections sub-sections or clauses mentioned in the first column of the following table or of any regulation made thereunder or

(b) failing to comply with any requisition lawfully made upon him under any of the said sections sub-sections or clauses continues to contravene the said provision or to neglect to comply

(3) If within the period prescribed in an order made under sub-section (1) the provision is not carried out or enforced the Governor in Council may appoint some person to carry out or enforce the same and may direct that the expense of carrying out or enforcing such provision together with such reasonable remuneration to the person carrying out or enforcing the same as the Governor in Council shall determine and the cost of the proceedings under this section shall be paid out of the municipal fund

APPENDIX II

MALARIA BUREAU BULLETINS IN THE HEALTH BULLETIN SERIES

No 1 Lectures on malaria. By G Covell 4th edition 1948 As. 5 or 6d.

No 2 Synoptic table for the identification of the anopheline mosquitoes of India. By S R Christophers J A Sinton G Covell and P J Barraud 4th edition revised enlarged and illustrated by I M Puri 1947 Re 1/6 or 2s. 6d

No 3. Antimosquito measures with special reference to India. By G Covell 7th edition 1946 As 8 or 9d

No 4 Table for the identification of Indian fresh water fishes with description of certain families and observations on the relative utility of the probable larvivorous fishes of India 2nd edition revised and enlarged by S L Hora and D D Mukherjee 1938 As 7 or 8d

No 5 Instructions for collecting and forwarding mosquitoes By J A Sinton 4th edition revised by I M Puri 1940 As 8 or 9d

No 6 How to do a malaria survey? By S R Christophers J A Sinton and G Covell 5th edition 1944 Re 1/12 or 2s 6d

No 7 Synoptic table for the identification of the full grown larvae of the Indian anopheline mosquitoes By I M Puri 6th edition 1945 Rs 3/6/ or 5s 6d

No 8 The distribution of anopheline mosquitoes in India By G Covell 2nd edition revised and brought up to date by I M Puri 1936 As 6 or 8d

No 9 A practical entomological course for students of malariology By P J Barraud 4th edition revised by I M Puri 1948 Re 1/12 or 2s 6d

No 10 Man made malaria in India By J A Sinton and Haja Ram 3rd edition revised by G Covell 1949

No 11 Handbook of common water and marsh plants of India and Burma By C C Calder and K Biswas 1937 Rs 2/12 or 5s

No 12 Prevention of malaria incidental to engineering construction By H W Mulligan and M K Afridi 1938 As 7 or 6d

No 13 What malaria costs India? By J A Sinton 1939 As 14 or 1s 3d

NOTE —These bulletins are obtainable from the Manager of Publications, Government of India Central Publication Branch Civil Lines Delhi.

INDEX